THE INSTITUTION OF PRODUCTION ENGINEERS JOURNAL

THE INSTITUTION OF

PRODUCTION ENGINEERS JOURNAL

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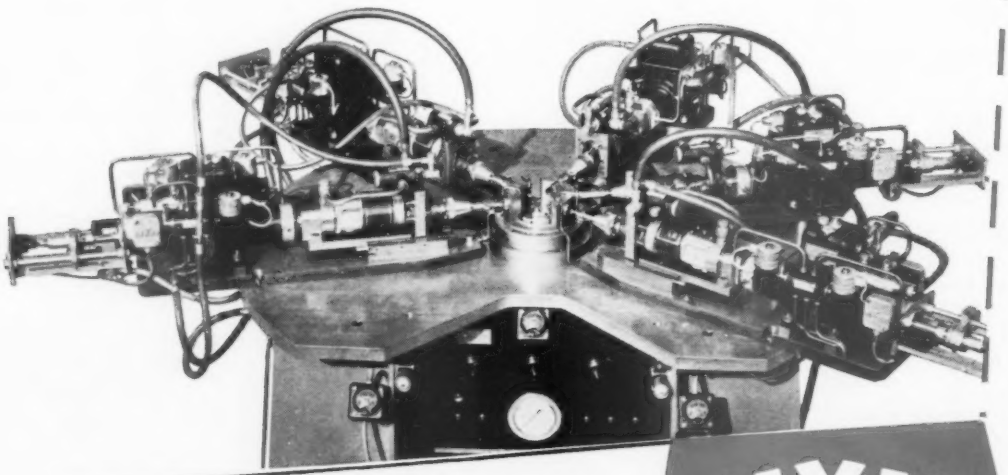

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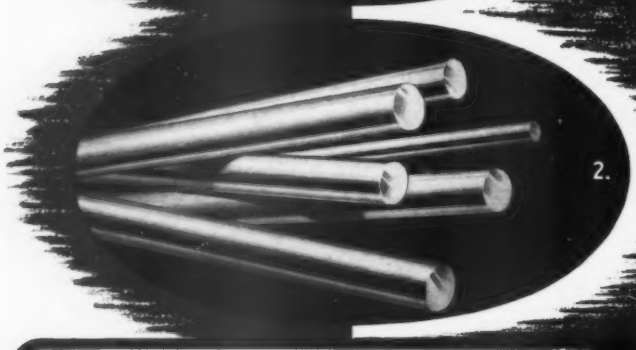

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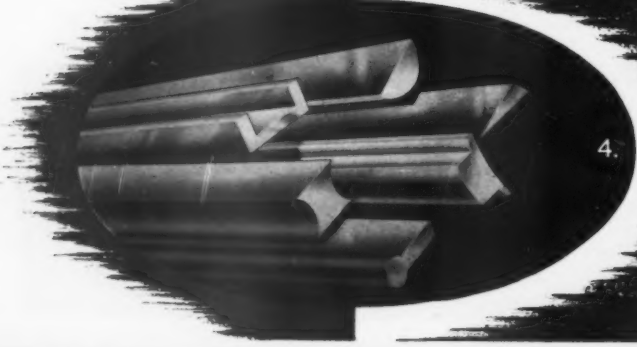

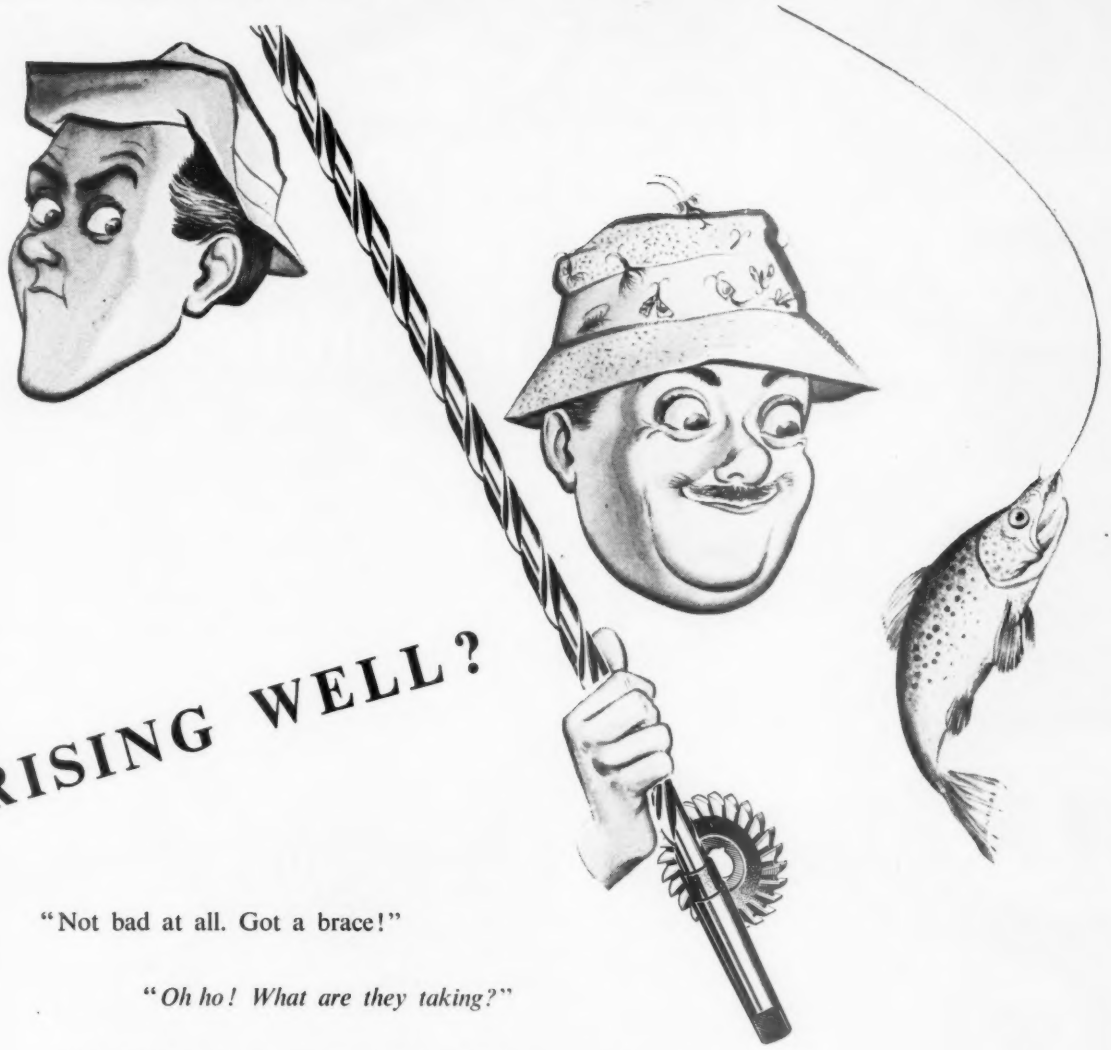

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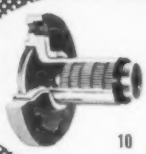
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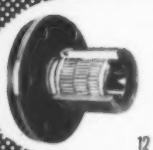
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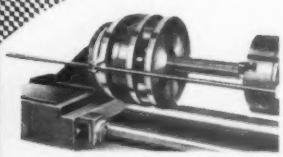

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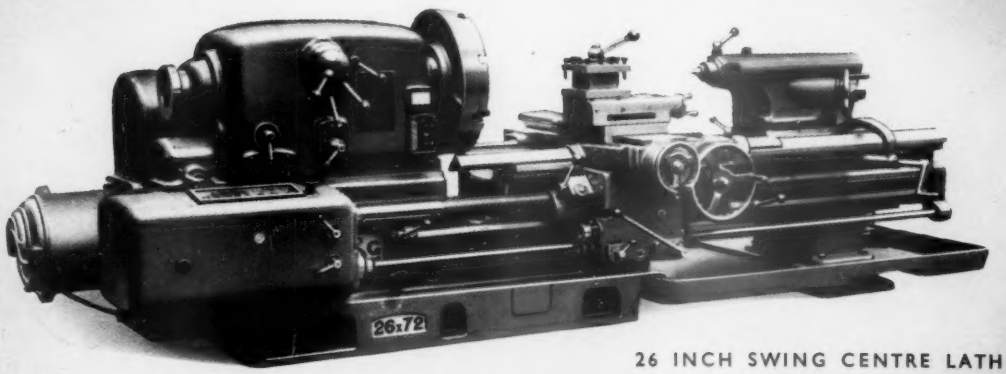

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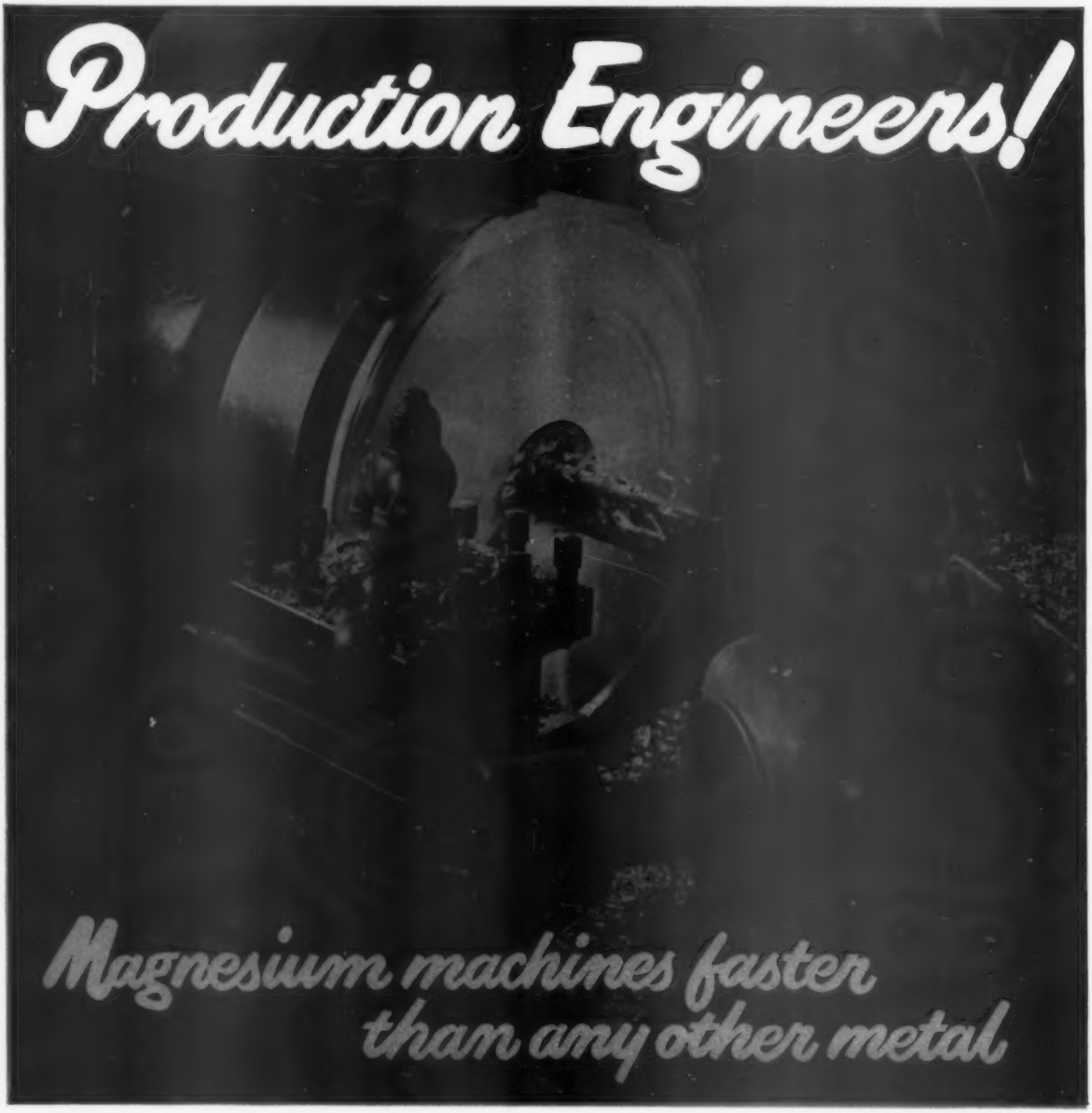

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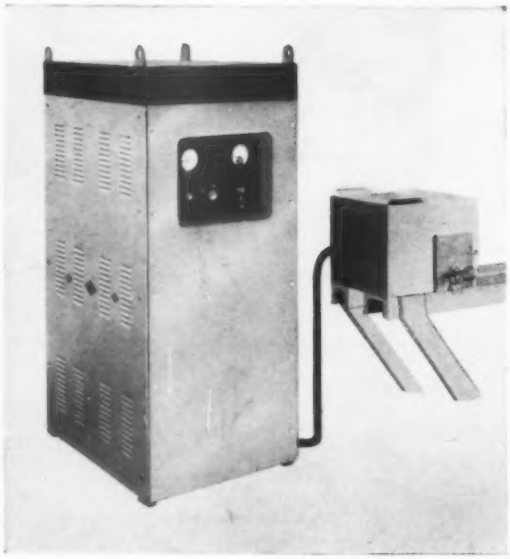

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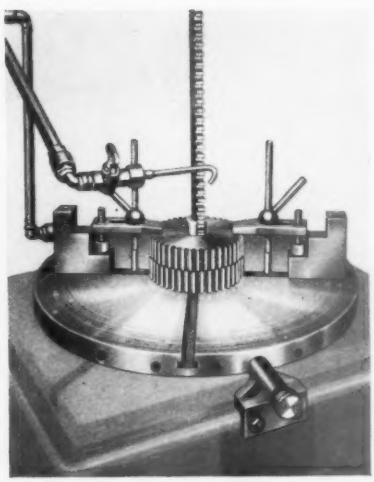

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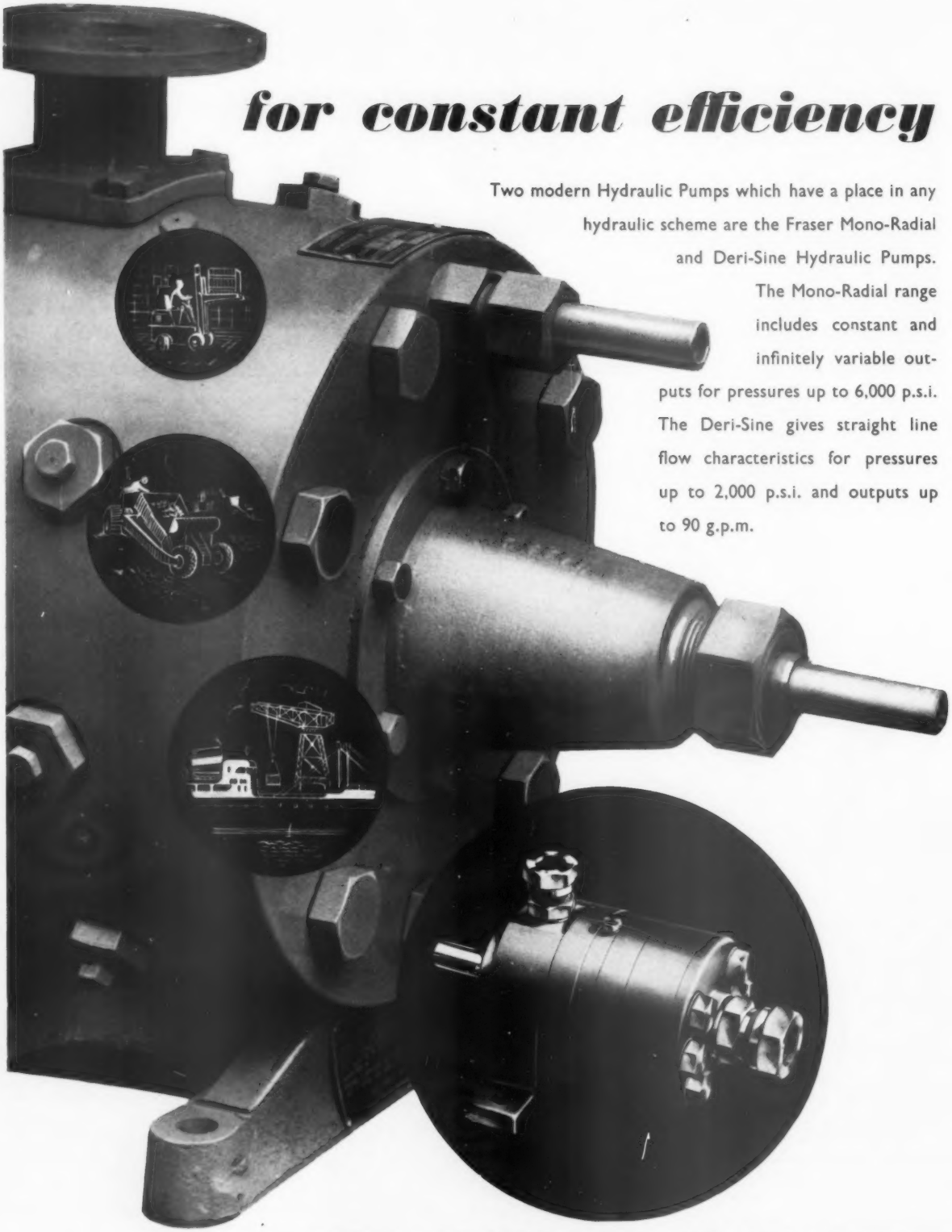

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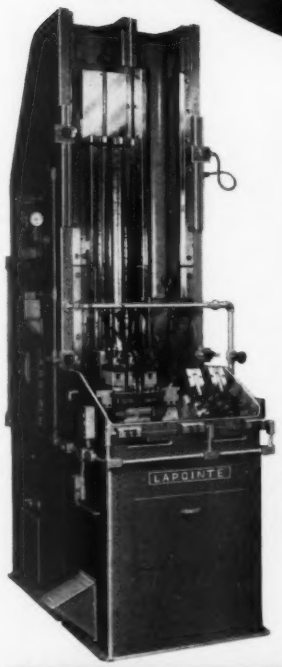

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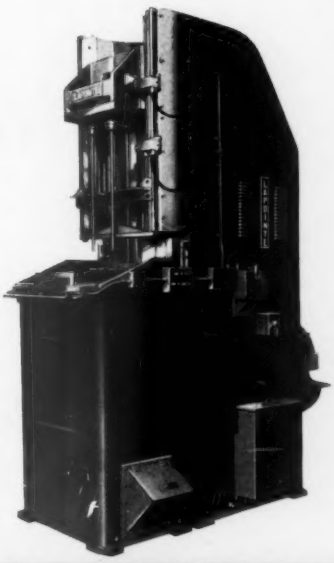

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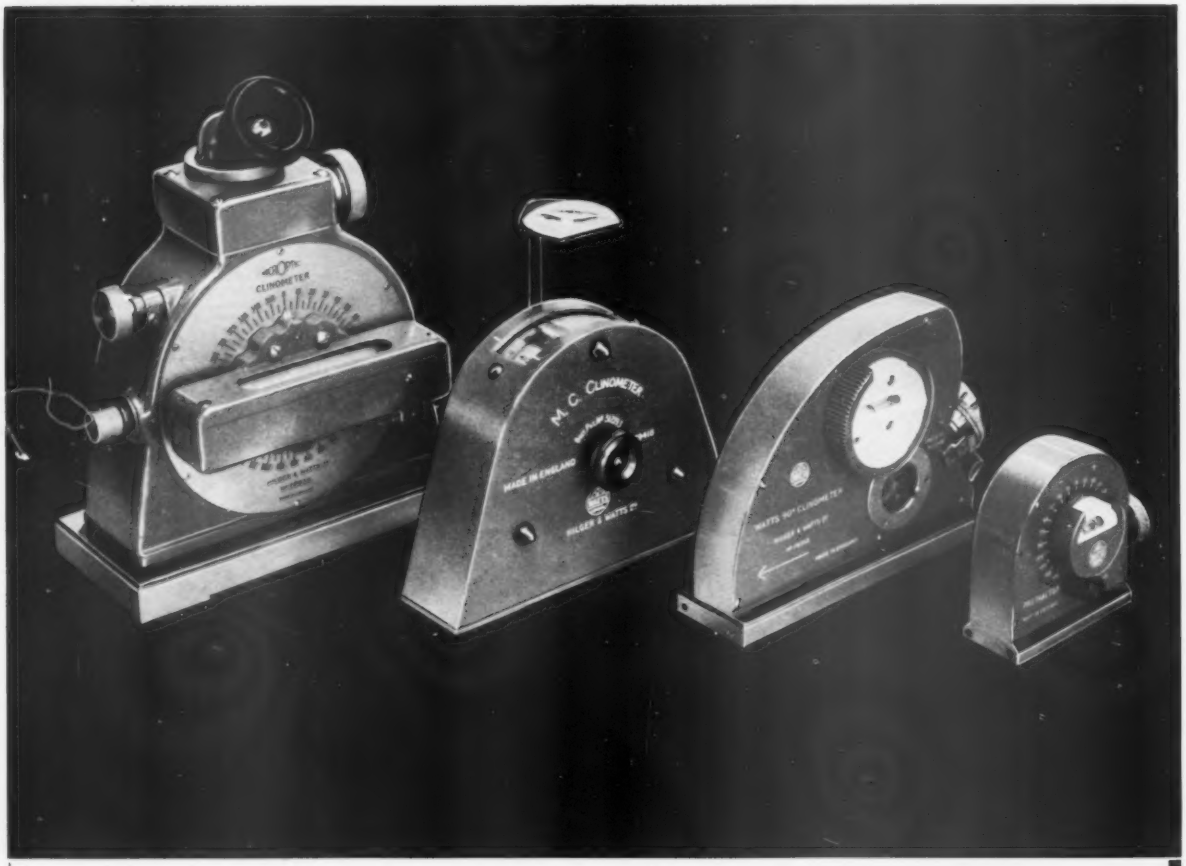

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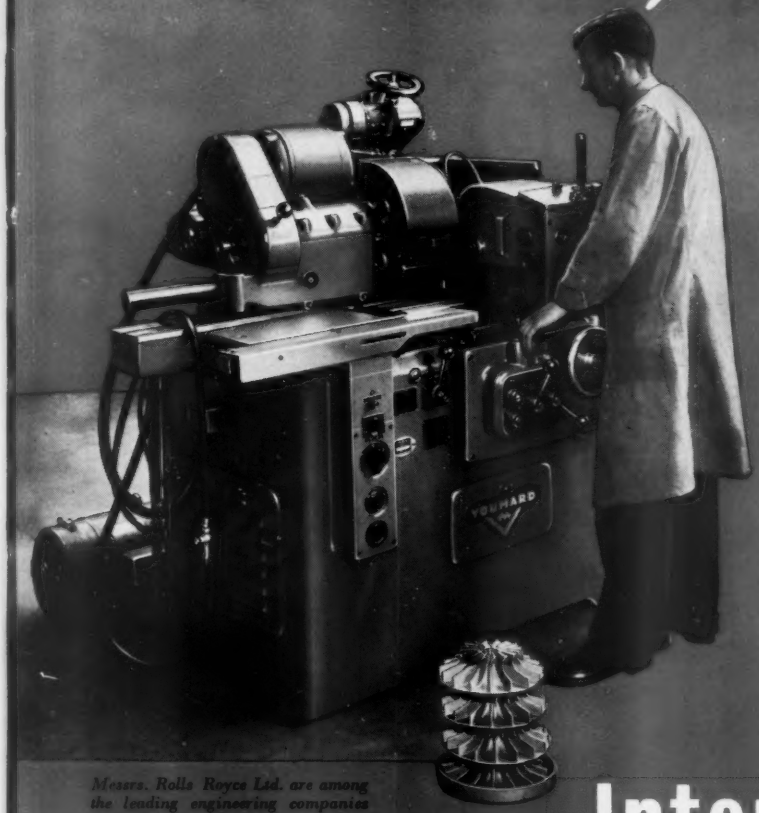

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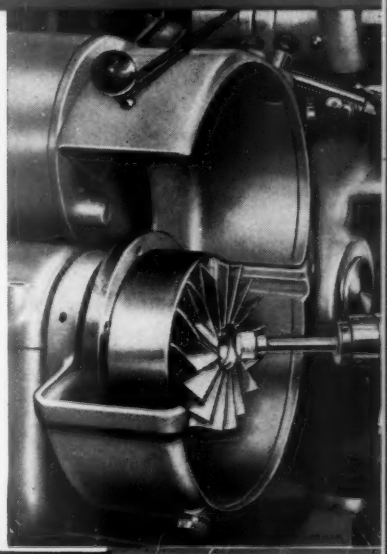

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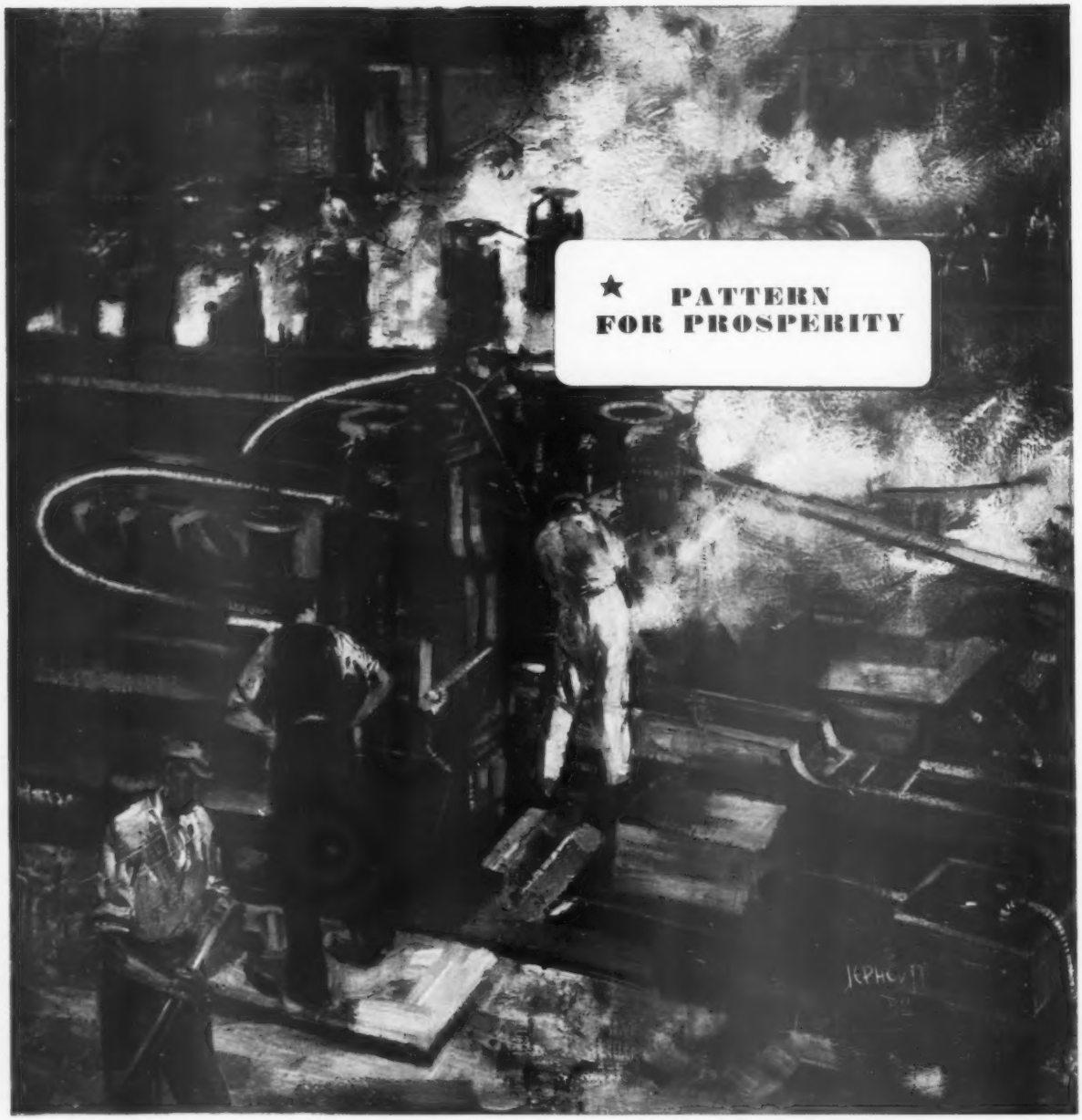

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The Institution of Production Engineers Journal
VOL. 33 NO. 3. MARCH, 1954

A New Dragon for St. George

by E. G. BRISCH, Dipl.Ing., M.I.Mech.E., M.I.Prod.E.

Managing Director, E. G. Brisch and Partners, Ltd.

ORDER books are dwindling, competition is coming from quarters that have been dormant for so long that we had forgotten them, and the campaigns for increased productivity take on a new note of urgency. Speeches in the provincial gatherings of the new Productivity Committees, and exhibitions and films are drawing attention to all the familiar ways of increasing productivity. Improved machine tools, improved processes, labour-aiding devices, increased application of work study, and all the business appliances from new machine-loading charts to electronic computors—all of them are out to appeal to what by now are our somewhat jaded appetites. With the increasing difficulty of raising capital and the incessant demand for wage increases, our enthusiasm for adopting these devices is tempered with caution.

While all these developments are tending to increase the complexity of production, another dragon is rearing its head which may well have us by the throat if we are not careful. The enemy is *clutter*. Profusion of stocks and proliferation of varieties, whether in the cause of progress, or to please the customer, are leading to bulging stock rooms, crowded drawing offices and increased overdrafts at the bank. This dragon is no relation of the old and familiar enemies which have always fought against frugality—overpurchasing, hoarding or the retention of obsolete stock. It is far less obvious, far less recognisable, much more insidious, more devastating in its effects and more difficult to remove. A simple purge will not be effective. Nothing but vigorous scrutiny, careful and accurate identification, clear orderliness and a deliberate policy of simplification will restore balance and economy to our elements of production: materials, products, and tools.

The money involved in unnecessary variety, taken over the whole country, is a vast and criminal sum. Between 20 per cent. and 80 per cent. of varieties of materials, components and tools have been found to be superfluous in various undertakings, large and small, throughout the country, amounting in extreme cases to as much as 30 per cent. of the value of all stocks. And it has to be remembered that the total annual cost of holding stores, including cost of capital, rent, handling, purchasing procedures, insurance, and losses due to obsolescence, and pilferage is at least 15 per cent., of its total value. In many industries this cost of holding is nearer 25 per cent.

It is not only the large undertakings that are guilty—even a small firm with 2,000 stock items and 15,000 component drawings can be found to be riddled with this wasteful disease.

The Evil of Unnecessary Variety

Apart from a few notable exceptions, there is a failure in our industries to understand fully this aspect of productivity. The emphasis for years on processes and methods has caused manufacturers to overlook the evil of unnecessary variety. Variety in the end-product is the spice of life. We depend

on pleasing a wide variety of customers, and quality of service must match quality of finish. We must give the customer what he wants. We have no large standard market, backed by huge advertising campaigns to make a standard product acceptable. But it is imperative that this necessary variety in our products is produced from minimum variety of their components.

This variety of components must itself be obtained from the minimum variety of materials, machine tools and equipment. Those minima must, of course, be economically justified, but must approach as far as we can the "Meccano" principle of an ever-increasing variety of products flowering from the stem of a basic minimum of materials and components.

The solution lies, as always, in a return to first principles. At the very moment when the designer's sketches have to be interpreted in terms of reality and the first parts come to be drawn, we ought to ask ourselves: "What do we possess at this moment and what can our suppliers provide?" So long as we do not require the fabulous billiard table (you may remember, it was circular with dozens of pockets, corkscrew cues, elliptical balls and a whacky assortment of equipment), we should resort to our existing stock lists and component drawings. This is where the trouble begins.

The Problem of Identification

Identification itself is a fundamental problem and must be dealt with in the first place. Descriptions are ambiguous, nomenclature misleading, similar items given different numbers or names, different items the same name. Forty different names for a metal disc; a dozen different brand names for the same material; meaningless component numbers hidden under old contract numbers, draughtsmen's initials or old Spanish customs. "Identicals" alone can be responsible for as much as 10 per cent. unnecessary variety.

The next stage after removing ambiguity and duplication is classification: the systematic grouping and arrangement of all items. There must be a place for everything and only one place. Common features must be determined and essential differences recorded in order to make comparisons and the best selection possible. Code numbers are then assigned, unambiguously defining each particular item. The code must be simple to use, self-explanatory to shop clerks and storemen, foolproof and easy to maintain. It must be flexible and capable of reasonable expansion.

This classification and coding can do much morethan help the user to find an ever-increasing number of items; it can go further and make sure that every item in the company's inventory does justify its existence. For any given requirement it can reveal all the items which might meet it, and for any one item it can reveal all the requirements which that item can meet. This means that a crucial decision can be made to enable the manufacturer to make the best use of the available resources. All the facts are there.

Here is the tool to kill the dragon.

It is not a mass-produced tool: there is no "off the peg" remedy. The deeper one descends in the hierarchy of specifications, the more individual to each firm become the requirements which your classification must meet. The characteristics expressed in a code must be those which correspond to the user's own specific needs. They are selected, not only by their nature, but also by their relative importance. For example, types of rubber having similar di-electrical properties would be grouped together but subdivided according to some other property, such as resistance to chemical attack, if this is of less importance to this particular enterprise. In a chemical factory, on the other hand, the same families of rubber might be more appropriately grouped together according to this property of resistance to chemical attack, but subdivided afterwards according to their di-electrical properties. A property such as colour might be of great significance to one user but of no importance to another. The most essential task which a classification specialist must carry out is the early discovery of those characteristics which constitute a common denominator of the particular user's requirements. These characteristics provide a clue to all the possible uses to which the items may be put, throughout the whole organisation.

For example, in a mechanical engineering firm, one of the first characteristics in the classification of components is shape. This provides the clue to less permanent characteristics such as the material of which it is made, the method of manufacture and its function. Notice that function might well come last for the purpose of classification. It is common practice to describe the components by names related to a function, thus tying them to a particular assembly, instead of making them common to as many assemblies as possible. This is one of the paradoxes of sophistication—the natural way of doing things is not always the most profitable in the circumstances. It is clearly of great importance at the stage of designing a component to be able to find quickly all the previously manufactured components capable of meeting a certain definite need, irrespective of the way they are made, the assemblies they were used in, the function they performed, the name they were given or the man who first thought of them.

This process of classification according to the permanent characteristics established from the user's point of view will in itself reveal a great deal of unnecessary variety. Thousands of items for which there is no justification are thrown up. These can be eliminated gradually without loss in various ways, either as such or used as substitutes or converted.

The possibility of quickly finding alternatives and substitutes is an important product of classification, not only as far as materials and piece parts are concerned. In one factory, 10 per cent. of press tools listed as redundant were found to be convertible at one-third the cost of new tools.

The sum total of these economies, the elimination of "identicals", of "drones", and the conversion of other items, has meant for several firms that they have been able to put to good use their apparently redundant and obsolete stocks in a few months, instead of selling them for scrap.

Simplification

The next stage in this slimming campaign is the inculcation of improved habits, the dieting process known as simplification. With the knowledge we now possess it is possible, without in any way endangering the variety of end product, to eliminate a great deal of superfluous variety in materials, components and tools. It has been proved that by these means savings of up to £50,000 per annum are possible in organisations employing about 4,000 people. Yearly savings of £10,000 have been obtained in the Drawing Office alone.

Since everything which is analogous from the point of view of the particular user has been brought together, a glance at the catalogue will soon reveal "areas of density" in respect of types or sizes. These are suspicious. It is certain that close scrutiny will reveal that a substantial part of the range is quite unnecessary. It is then possible to agree on a selection of preferred sizes and types which can be standardised within that particular firm.

The value of classification and coding of this tailor-made kind is not so much in the "cure", the release of stock and therefore of capital, spectacular though this may be. The abiding value of it as a tool for management is that it enables us to make better use of existing resources. It is a good discipline for designers, since it makes them justify each innovation. It provides a guiding method of thought which brings benefits to all parts of the factory, whether in helping the filing of drawings, the loading of machines, the location of parts in the store, or the provision of alternatives and substitutes that can be vital in emergencies.

The principles and techniques discussed apply not only to engineering but to any industry—from textile, chemical, mining, to public transport and the building trades, but the tasks of identification, classification, coding, simplification and finally standardisation are laborious and call for specialised skill. The latter has evoked the emergence in Europe and the U.S.A. of yet another type of engineer, the classification specialist. He fights for a vast field of economy against an enemy particularly skilled in camouflage. We are a nation of individualists; we love variety, we like to be different, but it is only the desire for the *visible* variety, the *visible* difference, that we really wish to satisfy. We have allowed our designers and planners to be a little too different for a little too long about the *invisible* wasteful variety —and lo, we have a new dragon in our midst.

PRODUCTIVITY — ARE WE ON THE RIGHT ROAD?

by The Rt. Hon. Lord SEMPILL, A.F.C., F.R.Ae.S., Hon.M.I.Prod.E.
Past President of the Institution.

Presented to a General Meeting of the Institution at the Royal Institution, London, on 16th December, 1953.

ON the eve of The Industrial Revolution that made Britain, for nearly a century, the workshop of the world, Carlyle, praising the spirit that had animated those who followed the Christian ideal established by St. Augustine, and implicit in the words "*laborare est orare*", wrote :—

"Older than all preached gospels was this unpreached, inarticulate, but ineradicable, forever-enduring gospel; work and therein have wellbeing."

The Council have done me honour in selecting me from among the Past Presidents, who number some of the leaders in industry, to deliver this the first Nuffield Annual Paper.

This discourse will remind those who follow on how much we British as a race, and production engineers as a body, are in debt to William Richard Morris—the Rt. Hon. Viscount Nuffield of Nuffield —a Past President to whose inspiration and benefactions we owe so much.

It was desirable to select the right day for so important an occasion. Since the key to a greater productivity is transport, this is surely the right day since tomorrow, the world will remember, and we of the aeronautical fraternity will be met to mark, the half-centenary of the first free and controlled power-driven flight in a heavier-than-air machine by Orville and Wilbur Wright. So "let us now praise famous men", for their work continueth broad and deep—greater than their knowing.

Production and Productivity

Engineers, economists and politicians make frequent use of two words, Production and Productivity. We are apt to think that these, so often used together, have one and the same meaning. This is not so, since the word Production is a definition of quantity, a measure of the products that result from an action, process or effect. This varies as well we know, and this fact was realised over three centuries ago in the words "a mountain may travel and the product be a mouse". We have seen this in our day! Productivity is a definition of the quality of being productive —it is a yardstick, a standard of perfection—the ideal to be aimed at in the selection and assembly of the best to be conceived by invention, design and development.

The effects of Lord Nuffield's pioneering in mechanical transport is writ large in the pages of history. His work is of international significance and, linking up with that of his famous counterpart of the United States, brought the motor car to the majority wherever they live. Lord Nuffield has helped to further transport in the air and on the sea. He is an old friend, and those of us who are lucky enough to claim this privilege know but too well that the quickest way to his "black book" is to talk of the man himself. I will, however, and must, declare my thoughts and say that his main contribution to our day has been more moral than technical. Through his life he has worked without sparing himself, and has shown up the way to do the things as he sees them for the God of all things as they are. If his vision proved correct, as so often it did, you and I benefited by getting the device quickly and at an economic price, while our children, the founders of the next generation, benefit in health and knowledge through The Nuffield Foundation or the work of one of the many bodies engaged on research and development as a result of his multifarious benefactions. As a Past President of the Institution and on behalf of all production engineers, I pay sincere tribute to our most distinguished Past President without whose example, guidance and foundation, the Institution would not be where it is today. The Institution, young in years compared to the "Big Five", feels with modest pride that it is showing its worth and will give place to none in its determination to follow in the highest traditions of the art and science of production engineering, and so continue its own special contribution to the benefit of all, and the security of the free world.

(Courtesy of "The Machinist")

Lord Sempill delivering his Paper.

It is a privilege to be selected as the first Nuffield Lecturer, and as such to have the advantage of a wide freedom of choice as to the subject. The Lecturer could discourse at length on the strictly technical and explain in detail how, due to the progress in production engineering, it has been possible to reduce the time taken to turn out an automobile from 104 man-weeks forty years ago to less than six today. It would be suggested that such progress in time reduction was continuous, or could continue, if the most up-to-date capital equipment was installed as soon as developed. For example, by extending the use of automatic transfer machines. The development of these has made the automatic factory possible. There is no limit to the number of operations that can be performed; in fact, in the U.S.A. the idea of the automatic transfer machine has spread like a prairie fire, and one may find some 75 machines coupled together with automatic transfer equipment from one to the other. This would allow the cutting down of the number of operators by less than one-sixth of the present total. It is not the intention to go into details of this new development of automaticity, but it is appropriate to remark that in relation to the man-week figures quoted for automobile production, they show that productivity has increased some 1,700 per cent. in the forty years. Similar improvements, of course, may be noted in other industries.

Lord Nuffield's work must be viewed over a far wider field than that strictly relating to the art and science of production engineering which, important as it is, shows but one side. The problem before our country is that of productivity, and it is the purpose of our Institution to speed its most rapid increase. To achieve this essential end at as quick a rate as possible, there are other things than the purely scientific or technical to be considered. The greatest bottleneck today is psychological, and unless we can overcome this we shall not be able to maintain, let alone raise, the standard of living of today.

The human problem is not a new one, but has become greatly accentuated by war neurosis, the illusory idea that the Welfare State, if pressed hard enough, will always pay, the crushing of the personal factor by an evergrowing bureaucracy, coupled with the chemical loading of the bulk of the food we consume. For the reasons broadly touched on in the above paragraphs, it is felt that a Paper such as this should survey the various aspects, whether technological or psychological, that go to make up the problems surrounding a greater productivity, the rapid and effective solution of which is so essential to our national wellbeing.

The greatest challenge to British achievement is the fact that we will persist in complacency and continue to assess what we are doing as against what has been done, rather than accept the challenge of comparison ourselves with what could be done. We are not facing the challenge squarely, and without a rapid change of attitude it is doubtful whether we shall survive the world-wide revolution of our time. This finds us in a position more vulnerable than any other country. There is much to be done, not only on the floor of the shop but within the industrial machine. It is the aim of this address to draw attention to these questions with a view to stimulating discussion over the widest field that will lead to action.

Productivity Reports

The Productivity Reports which are the result of the visits of some 70 British Teams to the U.S.A. (about 200 altogether from Europe) have been of the greatest interest. You will all, I feel sure, agree that they reach one common conclusion, and that is the very wide difference in the "attitude of mind" between our friends in America and ourselves. There were, of course, a variety of other points, and a full discussion of these was certainly of value to us--one has heard on more occasions than one that the same view was held by our friends on the other side; but what really governs the situation is the human factor. These Reports show that our industry is operating at plant productivities one-half or less than that of their American counterparts. For example, when one of our boys pulls a handle or presses a button, one-third or less material moves than when his American counterpart does the same.

When a country has achieved a high productivity level, this gives her surplus resources which may be used to instal additional and more up-to-date equipment. The U.S.A. is in that position, but unfortunately we are quite a way behind, being frustrated by the shortage of skilled personnel, too many of whom

are engaged on operating low productivity equipment. We need fear a recession less than many other countries, where production is already at a high level, since we have a large pent-up demand arising from arrears caused by the War, and a vast potential of domestic improvement in housing and roads.

The Technique of Transportation

Since the dawn of machinery concentration has been on the technique of making things but little attention, until recently, has been given to the technique of moving things. This has to be qualified, since considerable success has been achieved in the science of transportation over long distances. The other aspect to which attention has been given is the development of time and motion study. It is clear, therefore, that success has been met in moving things over vast distances as well as for moving things at arm's reach. The gap between, that of " short range transport ", has been ignored and it is only comparatively recently that attention has been given to this problem. It would be true to say that whereas we lead in the invention, design and construction of handling equipment, we fail to apply it to our own industry. It is very difficult to sell such equipment to other countries when the makers thereof can point to very little use in our domestic field.

The importance of " short range transport " may be illustrated by considering materials lying in a certain plant for 240 hours, of which time only 10 hours was devoted to actual processing of the material—a manufacturing efficiency of only 4 per cent. It is not necessary to say more except to reflect on the expense of the investment which in its turn demands excessive storage and handling facilities. A careful study in different fields shows that materials handling costs may vary from 30 to 90 per cent. of the total production costs. It is not necessary to stress the importance of this aspect by further examples, except to quote from the same study that for every ton of finished product despatched some 50 tons of some kind of material entered the factory. The ultimate objective of " short range transport " is to reduce unit production costs, and this may be different from reducing materials handling costs.

As has been pointed out, we lag in the use of mechanical handling appliances, though we may claim to lead in their design. One of the most interesting British inventions of the day, that of fluid drive, is being more widely employed in other countries. This invention makes possible the transmission of power with a control of application superior to that of steam. Every phase of industry is touched by one of the most important developments of our day, that of electronics, without which it would be impossible to achieve that high rate of productivity that our future compels. The foundations of what has become a great science originated in Britain following the invention of the thermionic valve by Fleming, and later fundamental work by Watson Watt and his partners.

There are two great differences between the industrial machine of the U.S.A. and our own, first, the attitude of mind of those on the job, and second, the enthusiastic adoption of mechanisation in America and therefore higher productivity. Long ago the Americans adopted the idea of the late Henry Ford, that there is no limit in creating wealth, with the result that there is a burning urge to adopt any and all new productivity techniques and mechanisms. The operatives do not worry about the company doing well, provided their pay packets reflect a practical appreciation of this fact. With us the majority take the view that the creation of wealth is very limited and that all should be governed by the lowest common denominator.

The late J. K. Jerome was a well-known writer and quite a philosopher, who says through the mouth of one of the three men in a boat, " I like work, it fascinates me, I can sit and look at it for hours; I love to keep it by me ". Now that was all very well in a boat, but we on this great aerodrome of the freedoms off the coast of Europe, with our 50 million people, have no time for such contemplations!

Invention, Research and Development

Though we still lead in inventive capacity, we are slow to adopt the products of these brains. We reward quite inadequately those who lead in the scientific field, the tutors of the inventors of tomorrow. This results in our making life so hard and unrewarding for those who have new ideas that they will seek every opportunity of finding a post abroad, generally in America.

The vital new industry of electronics is founded on developments springing from British inventions, as has been pointed out earlier in this Paper. The leadership we as inventors once had in production of the vast range of electronic equipment is passive, if in fact it has not already passed to America.

Our country has developed a new technique in electronic engineering, with which production engineers must be ever more closely concerned. This has as its objective the prefabrication of the complex circuits which most electronic instruments require. The mass production of the most complex circuits is now well proven and being increasingly used abroad. The invention is known as " printed circuits ".

In America there is hardly an electronic manufacturer of importance not using the process to ever greater extent. The technical journals give it great prominence. It is understood that one American firm is planning the production of television sets by " printed circuits " technique, and at the rate of one set each 22 seconds. To use a common phrase, it has " gone over in a big way ".

This is an example of " what should not be " and shows that in the application of British inventions to British industry we must be more alive, and not lose the export potential thereof as we have done in this case.

Expanding and Non-Expanding Industries

With us there is a great resistance to change, which varies in a marked way between the expanding and the non-expanding industries. The former, for example, include electrical generation and manufacture, aircraft, automobiles and trucks; the latter, railways, docks and coalmines. The former, seeing their increased output absorbed, are keen to adopt any improved techniques. The latter, seeing that the skill of production engineers is bound to reduce manpower, not unnaturally resist the introduction of labour-saving devices, which broadly speaking are only permitted if they do not do their job—save labour. The process of mechanisation, which in some instances though not perhaps being actively avoided, is certainly not being vigorously adopted, must be encouraged to the maximum. For a long time politicians have promised those in the non-expanding industries that they will not work themselves out of a job and can carry on happily until they reach the retiring age. Such a statement, of course, would imply that production engineers are remarkably inefficient, or that the industries themselves refuse to adopt any of the labour-saving mechanisms. As the development of mechanical handling proceeds, men are bound, in the non-expanding industries, to work themselves out of a job. The matter must be dealt with in a sympathetic and straightforward way. This entails the provision of housing, near new centres of employment to which hands no longer needed in, say, the docks, would be welcomed—I repeat, welcomed—as opposed to directed. Until this problem is settled in a human way, resistance to the adoption of new techniques and mechanisms will continue, with disastrous results to our industrial efficiency.

Merchant Shipping

All forms of transport are vital to our living, and in particular is this so in regard to merchant shipping. In the years prior to the last War ships spent some 230 days of the year at sea, and 120 in port. Today, with all the mechanical handling devices that are on the market—though not at the docks—the figures are 170 and 190. In other words, the time in port has increased by some 60 per cent.—an appalling thought when one considers what should be. The ships could be operated far more efficiently and carry a greater quantity of ton miles of cargo per year. The more rapid turn-round of ships and the carrying of more cargo per year is dependent on the raising of the standard of loading and unloading efficiency.

What can be done is well illustrated in Canada, where some 7,000 tons of ore per hour are being loaded into ships by a crew of 10 men. In an hour and a half that crew can unload a 10,000 ton freight train, which means that each man is responsible for shifting 700 tons per hour. That amount per man is a big figure as compared with our figure of about a ton per man hour for general cargo, and shows to immense advantage the value of these new techniques.

(Courtesy of "The Machinist")

The President of the Institution chats with three Past Presidents before the lecture. From left to right are Major-General K. C. Appleyard, C.B.E.; Sir Walter Puckey; Lord Sempill; and Sir Cecil Weir, K.C.M.G., K.B.E.

The Mines

The source of our national wealth and the product that made possible the industrial revolution of the last century was coal. Let us consider the present 15-year programme of modernisation and mechanisation which is under way, and will eventually yield 30 million tons more coal a year with 68,000 fewer miners. This programme will yield an increase of less than 2 per cent. a year per person employed, and will cost over the 15 years £500 millions. The result forecast is most disappointing. If the miners were to be paid all the increase in productivity that would result from the 15-year programme of modernisation and mechanisation, in terms of increased wages, they could expect about 4/- a week increase per year. This, of course, would allow nothing for reducing the price of coal.

To get some idea as to what is happening in the efficient handling of coal, it is interesting to look back over the last few decades and consider what happens to the coal in a power station. Take a medium size power station, burning some 1,600 tons of coal a day, which is about the output of a medium size pit. During the last 35 years, productivity in the handling of coal in power stations has increased as much as 18 times. As an indication of this, in 1915 it cost 6½d. to move one ton of coal from the wagon in the power station siding to the bunkers in the boiler house. Today, with wages approximately five times more than in 1915, it costs ¼d. This illustrates the remarkable difference in overall efficiency between the expanding and non-expanding industries. As has been pointed out, in the former, there is no question of labour redundancy and there exists keenness to discover, invent, instal and use labour-saving equipment. In the non-expanding industries the same urge, except in isolated cases, does not exist, it being damped down by the fear of redundancy. This is perfectly natural since human beings

are not, despite the bureaucratic insistence that they should be, economic units—just numbers. Unless the seriousness of the national situation is explained in simple language, the natural law of self-preservation will maintain, as it does, a high resistance factor.

How comes it that in the last 30 years the efficiency in handling the coal in a power station has increased 1,800 per cent., whereas in the 10 years or so ahead there will be an increase of less than 2 per cent. a year per person employed after the expenditure of £500 millions?

A far better result could be shown in coal mining by the following example. At a Northern pit the number of miners has been reduced during the past few years from 1,400 to 800, the output of coal remaining the same. The miners rendered redundant were absorbed into nearby pits. After the labour force had been reduced to 800, without any decrease in output, the working at the pit was reorganised on lines to suit new mechanical handling equipment and different operational techniques. As a result, output has been substantially increased. Admittedly, this illustrates the exception, and shows that with the right human touch it is not impossible—though very rare—for a non-expanding industry to equal in overall productive efficiency one that is expanding.

In the days of President Hoover a Congressional committee was established to report on the cost make-up of the average article in the shops. This report showed that some 60 per cent. or more of the cost was absorbed by a transport or handling charge. Investigations here produce no figures that would cause one to quarrel with those that apply in the United States. In these circumstances the speed, efficiency and economy of transport is vital.

The Railways

Let us look at another of the national enterprises, the railways and particularly that aspect dealing with freight. Some 90 per cent. of the goods trains dodder along at some 10 to 15 miles per hour average, since the braking system is as chancey as that of the fifty-year old cars that take part in the yearly emancipation run to Brighton. This miserable speed is determined by the safe distance in which the locomotive, with the aid of one brake wagon with its hand applied brake, can pull up a train weighing some 1,500 to 1,600 tons and consisting of some 50 or more unbraked freight wagons. The goods train has to be able to pull up within the same distance as a passenger train with its 15 coaches, travelling at 80 miles an hour! The solution of this "fantasy" is neither difficult or expensive, since by the fitting of continuous brakes to all goods wagons, freight trains could run with existing locomotives at speeds almost the equivalent of passenger trains. There are a few called "fitted trains" that do so. By bridging this speed gap the number of trains running could be increased, there would be a far higher all-round standard of punctuality, and the avoidance of those frequent "bottle-necks" at goods yards. Here is a way for the improvement without any great delay of the railway goods traffic, the life blood of industry.

Housing

It is a strange thing that the industrial revolution, which transformed so many of our industries, left the building industry almost unchanged. This state of affairs is not unique, and is to be found in other countries. As might be expected, the first to adopt mechanisation for building were our friends in America. They have vigourously adopted a production engineering approach to these problems, and since we have so great a need for better houses, built with less man hours, it is essential we should take stock of what can be and apply these new techniques and mechanisms.

The building and civil engineering industry employs some 1½ million people, with a further 400,000 in the building materials and components industries. This is some 8 per cent. or 9 per cent. of the working population, and is more than there are in agriculture and about equal to those in the engineering, shipbuilding and electrical groups of industries. The capital invested is large, since building and construction work generally account for some 60 per cent. of the total gross fixed investments. This compares with 50 per cent. in the U.S.A. The figure for Sweden is about the same as our own. What is happening with these vast resources in action? In 1950 the Girdwood Committee estimated that the man hours needed to build a given type of house in 1949 were 26 per cent. above the 1938/39 level. This was an improvement on 1947, but it represented a 20 per cent. drop in productivity compared to prewar days. Productivity, broadly speaking, has risen since 1938. The cost of a house expressed as a fraction of the national income is nearly 1/5 more than it was in 1938. There is a very close relationship between productivity in this industry and the use of machinery. The average American worker uses some 3½ times more electrical power than his British counterpart, and this is one of the reasons for higher American productivity. In other words, each American worker has some 60 or more hands to command and each British worker some 20.

Here is a tremendous field for mechanical handling. Take for example the building of two small semi-detached houses, and remember that much of the material is moved more than once and some 1,200 tons is moved on the site and by hand. There is nothing so expensive as "cheap unskilled labour".

Productivity in Europe

It is essential to keep an open mind, especially in the rapidly changing world of science and technology, and so the Anglo-American Productivity Teams' example has been followed. We should be aware of what is happening in countries nearer to us geographically, countries that have suffered more from war destruction than ourselves, such as Germany and Austria.

It is no exaggeration to say that while others work to live, the German lives to work. In the Ruhr some five years back, starvation was not only on the doorstep but in every home; order books were empty.

(*Courtesy of "The Machinist"*)

Among those who attended the meeting were (left to right): Mr. W. J. T. Dimmock, (Chairman, Institution Papers Committee); Mr. Antony Vickers, Director, Fluid Flywheels, Ltd.; Mr. E. C. Gordon England; and Mr. G. Ronald Pryor, Vice-Chairman of Council.

Today rationing has been abolished. As an example of productivity, the miners have increased their output per shift by 70 per cent., order books are full, and in part from some of our traditional customers. The executives are well ahead in the field of "human relations", for example, by the establishment of supervisory boards of which the shop workers may elect half the number.

The achievement in production in Western Germany in so short a time, considering the manifold difficulties, is even more remarkable than in the United States. Western Germany must parallel our activities in the last century.

Consider Austria—the shining example in the world, of a country saddled with four occupying armies, who has remained wholly free and democratic. Not for one moment has she had to worry about the loyalty of her people in any of the four occupied zones. Vienna is the only capital in Europe fearlessly pursuing its own independent capital initiative, which other capitals have foregone. Unlike Western Germany she had no industrial machine ready to be started, yet in eight years she is Europe's largest oil producer, has established a steel industry comparable to that of Sweden, and become one of Europe's greatest timber and wood pulp exporters.

This is a tribute to that unique instrument of reconstruction, "Marshall Aid", with that vital all-compelling "happy ship" atmosphere that comes from those in whom the flame of the Christian ideal burns the more brightly since its attempted suffocation by the Nazis and those of like mind. Again, it must be emphasised that the success in recovery of these two nations is primarily due to the fact that the majority have the right psychological outlook of which "the human touch" whether in the field, in the office, or at the bench is the expression recognised by mankind.

Economics

We should consider as to whether the major slice of the modest total capital expenditure of industry has been devoted to the raising of productivity, or has too large a slice of it served to adapt industry to the slower pace or lower mobility of labour? If it is shown that the effect has been the *expansion of output* without significant rise in the *output per man hour,* this is a wrong trend that must be remedied —again the human factor!

Some three years ago it appeared that the post-war rise in American productivity had ended, and that we should be able to make up the leeway. Since then her industry has felt a new urge to an increased productivity by the introduction of electronic control devices. These have been applied with enthusiasm.

Since the amount we produce depends not only on our ability to produce, but also to purchase or consume, it is essential that this basic fact in our *power production world* be recognised and met by the financial system.

We have tried for too long to dam back the ever-growing flood of plenty, but man's inventive genius is beating us in that struggle. The advance in labour-saving devices goes forward. The financial system was made for man, not man for the financial system. It was invented by him to facilitate the production and distribution of real wealth, and instead it is now standing between him and the enjoyment of that evergrowing volume of material wealth which modern science and technology has made possible. History has shown convincingly how disastrous are the consequences when institutions blindly refuse to adapt themselves to changing conditions, and get in the way of irresistible forces.

The British Empire, comprising one-third of the population of the world, has a great opportunity and responsibility in this matter. In the last century we led in the technique and application of power to production. Now is the opportunity to lead by showing in practice how a new financial technique suited to the world of power production can work better than that devised to meet the circumstances of past centuries, which no longer maintain today. It is because of this growing gap between the forward-reaching world of economic facts and the backward-looking world of economic thought, that, whilst we are conscious of these glaring absurdities, we have been paralysed in action by the conflict in our minds between patent fact and cherished theory.

The vast subject of the financial system is not a popular one, but it must be tackled as it is important when suggesting a new line of thought to avoid creating a confusion of mind. It is well to remember when approaching it Lord Balfour's words of some 50 years back—"The generality of people much prefer the continuance of a problem which they cannot explain to an explanation which they cannot understand".

Conclusions

We are embarked on a new Elizabethan age, but have not yet settled down to the different tasks that

we must all perform if we are to do justice to the example of our predecessors some four centuries back. That we can do so I stand entirely convinced, and would say with modesty that if we make proper use of the inventions that spring from the genius that God gives to the few, we can equal and might surpass the record of that glorious age.

Our inventive and creative abilities are still with us, and in these fields we can more than hold our own. Over the centuries we have developed a way of life that most nations endeavour to follow. The road has been a hard one, and we have often tried things well in advance of others. If they have proved unsatisfactory we have discarded them. Some three centuries back we were dragooned under a totalitarian regime. Our forebears had no use for the "Police State" with its attendant horrors of prisons and informers. Our future cannot be secured by any robot-like regimentation of men and machines. We must fight against every attempt to destroy personality and make man a thing, whereas man is a person and freedom has its roots in his spiritual nature. Our proper future depends on inspiration that springs from the ideals of the spirit, and that spirit, that better self, latent in mankind has to be awakened. It is only by such an awakening that we can be brought to think, not narrowly of ourselves and our imaginary rights, but of our duties to our Christian civilisation, immature though it may be, its maintenance and extension for and by future generations.

In the opening part of this Address it was stressed that beyond doubt the key to the whole problem of greater production and general national wellbeing, lies in our attitude of mind. It is vital that our political leaders, together with the leaders in industry, through the B.B.C. and on the floor of the shop, should emphasise in simple language that we can all understand, the inescapable fact that unless we adopt a completely different attitude of mind towards the working of the industrial machine by the unstinted application of new techniques and mechanical handling devices, together with the throwing overboard of all restrictive practices by whomsoever applied, the lowering of our standard of life is inevitable.

No one can surpass the Prime Minister in finding words, never to be forgotten, to mark in our minds the urgency of the hour. A day or so ago he forged the phrase that fits the day:

"The power of man has grown in every sphere except over himself."

Let us practise this and prosper by gaining the victory over ourselves that self-discipline alone will bring.

(A film lasting some 20 minutes and several slides were used to emphasise the main theme of the Address.)

REPORT AND DISCUSSION

AT a General Meeting of the Institution of Production Engineers, held at the Royal Institution, London, on Wednesday, 16th December, 1953, at 5.30 p.m., the first Viscount Nuffield Paper, entitled "Productivity—Are We On the Right Road?" was presented by The Rt. Hon. Lord Sempill, A.F.C., F.R.Ae.S., Hon.M.I.Prod.E., Past President of the Institution. The President of the Institution occupied the Chair.

The CHAIRMAN, in opening the Proceedings, said that the year 1937 was a very great one in the history of the Institution. In that year, Viscount Nuffield did it the great honour of accepting its Presidency.

How unnecessary—in fact, how impossible—for him on this particular occasion to eulogise Lord Nuffield—to eulogise him as a great humanist, a great industrialist and a great President!

In a group comprising, as it undoubtedly did, a large number of industrial members it might be thought odd that he had put Lord Nuffield's human qualities first. But this was no accident: as Lord Sempill would shortly explain, the human factor was of transcendent importance to production engineers as to almost everyone else. There was no one present who had not appreciated over the years, or would not appreciate even more as the years went on, the great services which Lord Nuffield had rendered to the nation, services so many of which had sprung from his great human qualities. It was therefore no accident, as he had said, but quite deliberately that he had put his human qualities first.

Lord Nuffield was also a great industrialist, and one almost felt one should apologise for using such trite terms; because again there was not a single person in the room who did not realise the great contribution Lord Nuffield had made to this country in the field of industry.

Those who had perhaps not fully realised how great a man they were to honour that evening would, if they were members of the Institution, have read an appreciation of him by Lord Sempill in a recent issue of the *Journal*. No one would have forgotten —indeed, he doubted whether they would ever forget—that he had controlled a great enterprise, though he had just laid down some of his duties. Starting from humble beginnings in his own small shop, his business had grown and grown until eventually he had controlled successfully one of the biggest enterprises this country had ever known.

He was a man who at all times had his eye on the distant horizon, and he had always been aware of the human aspect. At the same time, he had a firm appreciation of the technical and organisational and production problems that were involved. He was truly a great industrialist.

A Great President

Lord Nuffield, finally, was a great President; he was a great President in two ways. He brought to the Institution the prestige his name brought to everything. At that time, it was young. It was still relatively young, but then it was very young and struggling. Lord Nuffield did it the honour of becoming its President, and it was grateful to be allowed to shelter, if he might put it in that way, behind his great prestige.

Lord Nuffield brought assistance to the Institution in another way: and there was no need for any apology here. Presidents who had a twofold advantage were not to be sneezed at! He had rendered the Institution great financial assistance. He had enabled it to purchase its headquarters at 36, Portman Square, and this was a great step forward in its history. In addition, in the following year, he had made a magnificent gift which enabled it to set up the first production research unit in this country at Loughborough College. Members would remember with what temerity (he thought he might use that word) great decisions were taken when it was decided to appoint that master of his craft, the late Dr. Georg Schlesinger, as the first head of the production research group at Loughborough College. This group, now under the umbrella of the D.S.I.R., was known at the present time as the Production Engineering Research Association, or P.E.R.A. All this sprang from the prestige, wise foresight and generosity of Lord Nuffield.

It was appropriate that there should be a Paper named after this great man. He would like to take this opportunity to pay tribute to the Committee of the Institution that had decided, with Council's approval, that certain distinguished men who had served the Institution well should have a Paper named after them, so that a platform could be provided every year from which their names could be brought before the members in recognition of their services. Lord Nuffield would approve—indeed, it was known that he did approve — not only the speaker but the subject, for the latter was one dear to his heart. He hoped that in succeeding years the Lord Nuffield Paper would afford a similar opportunity for the presentation of the problems confronting the nation. They would alter, and they would vary in intensity as the years went by. But he hoped that the speakers would rise to the occasion each year and would, in honouring that great name, place before the Institution problems, indeed for the attention of all citizens of this country.

What of the man who had been chosen to present the first Viscount Nuffield Paper? If 1937 was a great year in the history of the Institution, so was 1935. In that year, Lord Sempill honoured it by becoming its President. And in passing, he would like to say how honoured he himself was at following such a distinguished line of Presidents. He was delighted to see that evening his immediate predecessor, Sir Cecil Weir. Lord Sempill had been the close friend and supporter of the Institution for many years. He was, indeed, a founder member and what more could one say of his wide and imaginative outlook than that?

It was Lord Sempill who had persuaded Lord Nuffield to become President. What better service could he have rendered the Institution and who more fitted on this score alone to present the first Viscount Nuffield Paper? Lord Sempill had mingled with the great, and he had kept the Institution in touch with the world at large. One of his most endearing qualities was that he could always spare time for the younger members. He was Chairman of the Hazleton Memorial Library Committee which was concerned largely with the Graduate members. It was felt that the Library was essentially more important to the younger than the older members. Lord Sempill was willing at all times to work actively in the interests of the younger members. Thanks were due to him for his continued help and for the inspiration he gave to those who knew him personally.

A Remarkable Career

He had had a remarkable career. There was no need to give a chronological record of all the events in his life, for many of those present would know them well. It was sufficient to say that Lord Sempill was one of them in that he also knew what it was to serve an apprenticeship. He had served an apprenticeship with that great firm, Rolls-Royce. He was a man who knew shop terms—most of them! He could speak the language of the production engineer. He was a man to whom "production" and "productivity" were words fully understood and fully used over a long, interesting and successful life. He joined the Royal Flying Club in 1914 and he had taken great interest in aviation over many years. He could drive cars very fast in the pre-war years, and in visiting various centres of the Institution he had given some interesting exhibitions of car driving of which he (the Chairman) must remind him one day. Besides being President of the Institution, Lord Sempill had been President of the Royal Aeronautical Society, a great contemporary body that was helping to celebrate a great event during this very week. He was interested in a variety of other things, in addition to his many technical activities over a wide field.

It was quite in the style of the man that he should be seen, as on a recent occasion, standing up in the House of Lords with a loaf of bread, endeavouring to show that people were eating badly and were being slowly poisoned; that people should cook better and make better flour. It would be treading on dangerous ground to go too far, for he himself did not know very much about these matters. But Lord Sempill knew a great deal about them and he was foremost in attempting to bring them to the

attention of the British public. He himself had indeed been fascinated only a week or so ago when his wife had pointed out to him that Lord Sempill had drawn attention in the House of Lords to the poor quality of the dyeing of the kippers (it might have been haddock, but he thought it was kippers) that were offered to the nation today!

He mentioned these things not flippantly, but in order to show the wide range of interests of this man who had been chosen to present the first Viscount Nuffield Paper. He had the greatest pleasure in calling upon him to present his Paper on "Productivity—Are We On the Right Road?"

(*Lord Sempill then presented his Paper which is reproduced on pages 146/152.*)

The CHAIRMAN, in declaring the discussion open, said that many thoughts had passed through his mind during the past hour or so, and he felt sure other people were in the same position. They were indeed grateful for the panorama that had been laid before them in such simple human terms that each one of them had understood clearly what Lord Sempill had been driving at. He had given them a great deal to think about.

He proposed to ask Mr. Gordon England to open the discussion. He was a well known member of the Institution and only a week or so ago he had presented a provocative Paper to the Preston Section, in which he had asked some of the very questions that had been asked by Lord Sempill. It was fitting and appropriate that he should open the present discussion.

Mr. E. GORDON ENGLAND (*Consultant*) said that in his view such a Paper had been needed. He would not attempt to thank Lord Sempill for it: thanks would come later and he did not want to anticipate anything that would be said then.

The theme of the Paper was really a plea for a wider membership of the Institution. Members of the Institution must, he thought, drop their "parochial" attitude towards the definition of a production engineer. They should drop the idea that the production engineer was concerned merely with the manipulation of various metals and possibly plastics, but beyond that he did not go.

Lord Sempill had covered a very important field. He had dealt most ably with those things which went to securing productivity, and here, if he might, he would like to give his own definition of productivity. He did not accept Lord Sempill's definition: in a sense it was too limited, and he hoped the Institution would accept his alternative which was taken from a magnificent book of reference:

> "Productivity: the production of goods or services of exchangeable value abundantly."

The operative words were "exchangeable value". In other words, one could have production to the *nth* degree but if one could not get the goods consumed, one had failed and failed miserably to secure "productivity"; one had merely achieved "production".

That definition, if accepted, would bring them into line with Lord Sempill's Paper, because essentially what he had said amounted to this: that goods and services of all kinds produced by the nation must be readily consumable. In order to achieve that aim, it was necessary to get the production engineer into many fields where he was obviously badly wanted, but at present did not function as a "production engineer".

Lord Sempill mentioned, among other matters, the housing problem. It was surprising, however, that he had not mentioned a figure that had been published recently to the effect that only 25 per cent. of a bricklayer's working hours was spent in laying bricks. Here was a splendid chance of getting a few production engineers into the building industry, and he would like to see those discharging the function of production engineers in the building industry becoming members of the Institution. The Institution was not doing its job properly unless it covered the whole field of production in the country.

In that respect, some members had probably seen in the press only that day an account of the experience of a Mr. Vokes, who had decided to put production engineering into the housing problem. It was months and months before he was able to build his house because of official delays in granting permits, but once he was able to make a start his house was completed in six weeks. He merely used production engineering methods, methods he had learnt as a production engineer.

He would appeal to members, therefore, to give real practical expression to Lord Sempill's magnificent challenge and to see that there was a strong section of production engineers recruited from the building industry as a start in a much wider spread in membership.

What delighted him more than anything about Lord Sempill's address, of course, was his insistence on the "attitude of mind". This had been sadly neglected by the Institution. What study had they devoted to it? What had they done in the Institution to deal with the common factor in all the productivity reports—the difference in the "attitude of mind" of the people in industry in the U.S.A. and those in industry in Europe? It was both a criticism and a challenge that so far they had literally done nothing. But it was the dominant factor. Surely they had worshipped technology and so-called science and mechanistic concepts to the exclusion of the human aspect.

The human factor in industry was the dominant factor, but it was almost completely ignored. Reference had been made to it in the Paper Mr. Gordon England had recently given to the Institution at Preston. It had come as a shock to his Preston audience when they understood that no factory in the world, however good were its buildings, its machines, and so on, from the technological point of view and however fine its processes and material, that would not cease work if the human element was missing. The dominant factor in production, therefore, was obviously the human element. But was it

regarded as the dominant factor? Was that taught in the Institution? Lord Sempill had shown that it was not. It was time for the membership of the Institution to wake up and act.

He had administered another shock to his friends at Preston. He had asked them what was the dominant motive in man. They did not appear to have the foggiest notion! It was news to them when he pointed out that it was the "creative motive", yet appreciation of this "motive" was vitally important to production engineers.

In studying the human element, it was important to remember that the attitude of mind dominated the picture, and he strongly supported what Lord Sempill had said about this. Full appreciation of Lord Sempill's words was of vital importance to this country.

There was another thing he wanted to say. They had just seen a magnificent film. Some sixty-eight teams had been sent to America and he believed that there was a grave danger in wrong conclusions being drawn from these visits. There was a tendency to see in what the other fellow was doing some principle and to imagine one must follow him. This nation was doomed to very early extinction as a leading power if it followed other people. This film had a fascination for most people. It preached, as it was intended to preach, the leadership of America. It was implicit in the Paper—and this, he felt, was absolutely right—that this country must develop its own form of leadership. With its wonderful background, it could re-establish its leadership in a way which would stagger the world. It did not need any new techniques, any new machinery, or any new factories to double the nation's output. He made that statement quite dogmatically, and he held a conservative estimate. If that was so, what was wrong? Only one thing was wrong—the attitude of mind. As soon as the attitude of mind was put right, this country could "get going".

He realised that it was common for everyone—and he was as guilty as anyone else—to get annoyed with the people they had to manage. It was time that they got annoyed with themselves for their lack of understanding of the "dominant factor" in industry. When they got themselves right and began to see the picture in true perspective, they would find that the British working man would turn out to be what Henry Ford said of him to the speaker in 1929 in New York: "The British working man is the finest material in the world. The only thing is, you do not know how to handle him". And that was true today.

Mr. ANTONY VICKERS (*Director, Fluid Flywheels Ltd.*) said it was indeed a privilege to be allowed to join in the discussion following Lord Sempill's magnificent Paper.

He would like, in all humility, to say something about the importance of the attitude of mind. This varied in this country from being very good to being very bad. In his own company (though he knew one should not talk about one's own company) productivity had doubled in seven years. That was to say, there was four times the output with only twice the personnel. During the last miserable strike in the engineering industry on December 2nd, not a single man went out of the place. That was something!

But it was not so much about the attitude of mind that he wished to speak. No doubt the film that had just been shown would make one feel that the Americans had everything. They were splendid, of course, in many ways and particularly as regards production techniques. No one could dispute that. What puzzled him was this: were the Americans really on the right road?

He asked those present to consider for a moment the dominant financial centre, Wall Street—and Lord Sempill had referred to the question of money. What happened when international tension worked up to breaking point and war seemed inevitable? Wall Street went up much quicker than the curve of rising productivity shown in the film! On the other hand, when peace seemed to be a possibility what did Wall Street do? It did the reverse: it slumped right down.

What was the reason for this? Surely there was something strange if the many thinking people buying and selling on Wall Street went to such extremes. The reason was simply this: that the United States had not learnt how to use their resources fully except in times of preparation for war, actual war, or the aftermath of war. It showed that they did not know how to use their resources fully in times of peace nor, for that matter, did the Governments of other nations, including our own.

That brought him to the next point. In the matter of productivity—and everyone would agree that it was necessary to increase productivity in order to have more—it must be possible to consume what was produced. Otherwise there was no point in producing. That was why Wall Street slumped when there was a likelihood of peace.

There was a further point of great importance, namely the financial aspect, because productivity could not be increased unless production expanded. Therefore, it was somewhat surprising to learn of the dictum of a recent President of the Federal Reserve Bank of the United States who said:—

> "The fact must be recognised that however desirable on general principles continuous expansion of trade and industry may be, such developments must accommodate themselves to the actual supply of capital and credit available."

There was a good deal of onus, then, on the non-engineering fraternity to ensure that there was sufficient capital and credit. People had to suffer a seller's market—after a war it was almost inevitable to have a general shortage—but there was no sound reason why this should be followed by a buyer's market in which there were more goods and services than the market could buy.

In their annual speeches, company chairmen told their shareholders: "We are now entering a buyer's market and hence production is down"! He would quote a typical case, because he did not believe

productivity could be increased if production was reduced. This is what the chairman of one of the largest companies said in his annual statement this year :—

> "As we have consistently done since the close of the War, we must continue to seek every opportunity of increasing turnover and exports, of raising productivity, of achieving greater efficiency and lower costs, and of re-awakening in its widest interpretation the art of salesmanship."

Right enough, but a little further on came this :—

> ". . . it was clear that peak sales had been reached and therefore it was necessary to curtail output . . . Much short time was necessary for many of them with a consequent fall in their earnings."

If he were a wage-earner and his attitude of mind was normal, would he increase his output, or would he go out of the door on Thursday evening wondering why output had to be curtailed? One of the most fruitful ways of increasing productivity would be to focus more attention on the problem of the ability to buy.

There was one last point he would like to make regarding the non-expanding industries such as coal, railways, docks, etc. Sooner or later the politicians and others of that kind would have to speak the whole truth and nothing but the truth. As an example, he would refer to an industry like the railways, where there was a tendency for traffic to move on to the roads and for passengers to go by motor vehicle. If traffic did not increase, and it seemed unlikely that it would expand very much in industrialised countries, and if labour-saving devices were effectively introduced, the number of people employed would be considerably reduced. It was the only way in which they would cease operating at a high cost and losing money, thereby lowering the standard of living all round. It would have to be brought out that there must be a steady reduction in the number of people employed in the non-expanding industries if they were to be efficient and their productivity to increase.

It was no use saying, "Stand outside the gate, and there will be jobs for you next year". The only way was to realise that the employment of each man involved capital and credit so that they would be welcomed into other industries where they could do useful work which would raise the standard of living. The capital and credit of a nation—of all nations—would have to keep in step with their ability to increase productivity and production.

Mr. M. J. SARGEAUNT (*Editor, Machinery Lloyd*) said he disagreed strongly with Lord Sempill, who had given his Paper before the wrong audience as he was talking to the converted. There was no production engineer present who had not advocated these things in every way to his superiors on his board of directors. Moreover, the glad acceptance of hard work which was advocated by Lord Sempill was not necessarily the prime key to high productivity. A century ago, people worked their guts out, but they did not necessarily achieve high productivity, because they had not the technical tools behind them.

Many of the factories which the speaker had seen in this country, where people worked really hard, had low productivity because they were poor in the basic modern production techniques. They were, in fact, all characterised by an absence of mechanical handling devices and by a fundamentally poor organisation. He would go further and take an example from the hospitals. There was no doubt that the quality of the staffs of hospitals had fallen off since 1939. Because of new methods and drugs (equivalent to modern production techniques) such as penicillin, the modern hospitals were now more efficient units from the point of view of their real function of saving life, even with poorer staffs available.

Shell moulding was a typical instance. He believed it had been propounded on occasions by the Chairman, and it was referred to in the Institution *Journal*. Indeed, production engineers all over the country had advocated it. Yet this process, which was first introduced into this country in 1947, was, according to a recent Paper in Birmingham given by an expert speaker, applied to only one per cent. of the possible applications. That figure showed the poor treatment afforded to the production engineers who suggested and developed the process and was an indictment of the top managements who had not used their work.

The way to put over productivity was first to get at the Government on the questions of tax remission and other incentives to the highly productive, both firms and individuals, and second to point out to the people on the floor of the shop who did not like work that labour-saving devices would greatly reduce the manual labour required from them. They could, in fact, work at a very easy pace and yet have high productivity and, with it, high real wages. More efficient production techniques rather than hard working operatives were the real key to the situation, though a constant working rhythm must obviously not be neglected if the best was to be obtained from these modern techniques. In fact, however, most really efficient production lines themselves determined the rate at which the operators worked.

Mr. R. H. VARCOE (*Managing Director, Preminco Ltd.*) said the meeting had heard two very distinguished gentlemen talking about the "state of mind". He wondered whether they really knew what they meant. They did not say how it came about. When they realised how this "state of mind" had been caused, a cure could be affected, and there would be increased productivity throughout the whole of British industry.

The CHAIRMAN said he took it Mr. Varcoe was not attempting a definition.

In the absence of a clear definition, Mr. VARCOE took it that "state of mind" was an indication of the lethargy of the British working people.

Mr. W. J. T. DIMMOCK (*Chairman, Institution Papers Committee*) said the question of application led inevitably to education. In other words, how did one mould people's minds? Undoubtedly, one could not leave education out of the discussion.

Many people visited the United States, and he could not help feeling that they chose that country because they could understand the language more readily and being, as Englishmen, rather lazy they found it easier to understand what was going on. They came back very complacent. They said the standard of education in this country was infinitely superior; and, of course, that was true. Lord Sempill had spoken about fundamental research and had said that many of the inventions which had produced such wonderful results in the last fifty years had sprung from thought and work done in this country. To some extent, that must be the result of the educational system.

Nevertheless, it would be agreed that the American educational system was very application-minded, and this was important. If one knew what to do, one still had to do it. What Lord Sempill had in mind was, no doubt, that this attitude was one which brought about an action rather than one which led merely to talk and thought.

Good as the educational system might be, there was need for added consideration of this aspect of application-consciousness. The need for applying knowledge should be taught in the schools. Research and thought and invention, important as these aspects were, could bring about an increase in productivity only through their *application*.

Mr. F. A. OAKLEY (*Member*) said the lecture was worthy of an audience ten times the size of the present one. One speaker had suggested that it had been delivered to the wrong assembly of people. But it was not possible to overstress—whether to engineers or to others—the importance of character to this country.

The troubles experienced in industry over many years were now coming to a head because the great principles upon which this country had been built were being passed over too lightly. Lord Sempill had referred to this once or twice, but he had not dwelt upon it. He had touched upon the vital issues that affected all science and industry. However clever people might be in the technical sense, the human element must be foremost in all our dealings and relationships.

As an ordinary member of the Institution, of long standing, he could well remember the early days when the human element was considered very thoroughly. Unfortunately, very few of them had stuck to their principles. Labour and production and management problems would never be solved unless they began to be human and to appreciate one another's ability. There was no need to bring class into this: what was needed was individual knowledge of the right principles of life.

The CHAIRMAN, in closing the meeting, said that the time had gone very quickly and this was a tribute to Lord Sempill and his fascinating Paper.

It was the job of the Chairman to sum up and to suggest, if possible, what message people should take away with them individually. He had neither the skill nor the time to sum up as adequately as he would wish after such a magnificent Paper ranging over so wide a panorama. There were, however, one or two points that had particularly impressed him.

He would like first to comment on some of the remarks made in the discussion. Mr. Gordon England, as always, had been provocative. That was his nature and, if he might say so, it should be the nature of every senior member of the Institution. Mr. Gordon England had suggested that the Institution and its membership had the key to success in this particular field. He had said that they should not be parochial. He (the Chairman) hoped they were not as parochial now as they had been, and he hoped that the Graduates who would follow them would be even less parochial. In passing, he would say that it was disappointing that so few Graduates were present. It would have been a wonderful opportunity for more Graduates of the London Section to hear words of wisdom, even if they had not been able—though he was sure many would have been—to contribute to the discussion. This relative lack of Graduate attendance might be an indication of the trend of education, the trend of the Welfare State; he would leave that for the Graduates to answer.

Mr. Gordon England had warned them against slavishly following America, and everyone would agree with him about that. But many of them had been to that great country and they had every reason to be grateful to it for the things they had seen there which they were able to use in this country. But they must rely on their own common sense in rejecting what should not be applied here. Many members were now using existing facilities more effectively, and how well Mr. Vickers had underlined the point in quoting statistics from his own company. The present financial difficulties lent added emphasis to Lord Sempill's theme.

Mr. Vickers had made a very profound remark in referring to the relation between "production" and "productivity". Lord Sempill had unconsciously widened the gap, perhaps, but Mr. Vickers had brought them together again. How important they were to industry and society! It was obvious that productivity could not be increased if production was tending to drop.

One speaker had said that Lord Sempill was preaching to the converted. But were they the converted? Perhaps so; perhaps that was why they were there that evening. But with the greatest respect he would remind them of the phrase used when Training within Industry (T.W.I.) was first brought into this country: that "if the learner had not learned, the teacher had not taught". They should go out into the wilderness and teach. That was the job of the converted, the job of the keen senior members of the Institution.

The younger members should not worry too much about those so-called obtuse senior executives whom they could not for the moment apparently satisfy or

convince. They should keep pegging away, as Lord Sempill had kept pegging away. Sooner or later the unconvinced would be convinced, and what a great day that would be!

Mr. Dimmock had made an important point; that better application required better education. This tied up with the point about personal qualities which had been mentioned by another speaker. Education was not merely education in the various techniques. It was not just a question of passing a degree or indulging in science. It was education in the dignity of work and the importance of practical things; education in the worthwhileness of a wide range of activities.

He would not attempt to sum up all the points made by the Lecturer himself, but three things had impressed themselves upon him. The first was Lord Sempill's reference to human values. If he might say so with great respect, Lord Sempill had himself been guilty of minimising them, to some extent, in using the word "hands" instead of "people".

Personally he always tried—though he still had much to learn—to visualise man in a three-dimensional state, man with a combination of hands and heart and brain. By looking at him in this way, however humble or senior his occupation, one began to define and appreciate human values.

Production engineers had a more difficult job than almost any other member of the industrial community. The modern personnel manager—a very necessary modern growth—had come into being because of the realisation that men were more important than machines. The production engineer had been accused of regarding the machine as the be-all and end-all of life. He would suggest that the production engineer had the important task of marrying man to mechanisation.

At a Graduate meeting in Birmingham not very long ago, the production engineer had been called the destroyer of the working group. How true a phrase that could be! They did set out deliberately to destroy the working group, a most precious asset to the country. Unless they recognised this and were prepared, in making technical changes, to put back the human values they had destroyed, they would always be regarded in a negative sense and they would never achieve productivity in the fullest possible sense.

Several speakers had referred to the attitude of mind and nearly every Anglo-American Report referred also to it. How important it was! How vital it was to encourage people to have that flexibility and breadth of outlook which embodied what Lord Sempill had said! The lecturer had referred to transportation, and it was in some ways paradoxical that they were met to honour a man who had perhaps done more than anyone else in Britain to make cheap and rapid transportation possible. Yet they still had much to learn about it, for while they were producing more means of transportation, they were in some ways slowing the nation down over a wide range of activities.

They were meeting in a strange situation. They were meeting under the friendly shadow of Christmas with goodwill towards all men as its theme. They were also meeting under the shadow of a paralysing strike and a shut-down and slow-down in many industries. Never was Lord Sempill's message more vital and important to the British nation than today. One message that they might well take away with them and put into action was that no one man was more responsible for making things better than the production engineer.

He had great pleasure in asking one of his predecessors in office, General Appleyard, to propose a vote of thanks to Lord Sempill.

Major-General K. C. APPLEYARD, C.B.E. (*Past President of the Institution*) said he was not sure he liked Mr. Gordon England very much: he had mentioned quite a number of the points he himself had intended to make! He had also caught Mr. Gordon England out in two errors. He was hopelessly out in his housing period. Six weeks was a very long time to take to put up a house if one knew how to build it. The Minister of Housing himself went to tea only the other day, with two families, in what had been a green field twelve days before!

The hardest cut of all was when Mr. Gordon England had said that the Institution did not talk enough about mental attitudes, human relations, and things of that kind. They could believe him (General Appleyard) when he said he had three stock Papers with which he had been wandering round the country during the last three years—the last time as recently as Friday—and they contained nothing but these subjects.

He also had a grudge against the President, who had opened the meeting by saying a number of nice things he himself had intended to say about Lord Sempill. They saw before them, therefore, an unhappy man in some respects. On the other hand, they saw before them an extremely happy man, because they had one of the "named" Papers that evening and it was not a long technical paper, difficult to understand. It had been an inspiring Paper of a kind this country so badly needed. It showed a bit of what could be done and finished with the hope that it might be done and some illustrations of how it might be done.

He himself had seen the film on life in America some three or four years ago. He had been on the famous mission which was described as the most important mission to visit America since the Pilgrim Fathers. It was a mission on productivity in Western Europe. They worked from nine a.m. to one o'clock the next morning for fourteen days. They sat and listened to precisely this stuff on the American way of life until he was sick of hearing about the American way of life, much as he loved America and the Americans.

But there was something in the film, and the meeting was greatly indebted to Lord Sempill for showing it. It did what the Paper did: it pictured what could come to this country. Only the day before, a man had told him that one shovelful

(*Concluded on page* 182)

THE EFFECTIVE UTILISATION OF MATERIAL

by FRANK NIXON, B.Sc., M.I.Mech.E., F.R.Ae.S.

Presented to the Derby Section of the Institution, 14th December, 1953.

Mr. F. Nixon

After graduating at Manchester University, Mr. Nixon worked on gas and heavy oil engines before going on to the Royal Aircraft Establishment and, subsequently, the Engine Department of the Bristol Aeroplane Company, Limited.

He left Bristol in 1942, as Design Manager, to join Rolls-Royce Ltd. After spending some time as Chief Quality Engineer and Chief Development Engineer of the Installation Division at Hucknall, and as Chief Sales and Service Engineer at Derby, he took up his present appointment as Assistant General Manager responsible for New Manufacturing Processes, in 1951.

"MATERIAL Utilisation" is a term generally understood by engineers to mean that proportion, of material bought for the purpose, in the form of ingot, bar, forging, sheet, strip, tube, wire, and so on, which is converted into a finished product. While the exertion of a constant effort to improve material utilisation is highly desirable, a study of the subject in this narrow sense is hardly of general interest, since the ideal figures vary considerably according to the product, and what would be normal for a cable-maker, for instance, would be quite unattainable by a builder of machinery. In its most complete sense it could be taken to cover all stages from the gaining of crude ores, through their reduction, alloying, processing, fabrication and manufacture, which would be beyond the scope of a single Paper.

It is intended, therefore, to deal here with some of the factors influencing *effective* material utilisation, which is used as an expression of the success with which the available supplies of material may be converted by the labour, skills and equipment possessed by manufacturers, into products which will find ready sales in appropriate markets. This success in turn is measured not simply by prime cost, but rather by the value of the product to the customer, who will apply also criteria of efficiency, lightness, finish, durability, reliability, life, performance, appearance, or style, depending upon the product and its particular application, before making his choice.

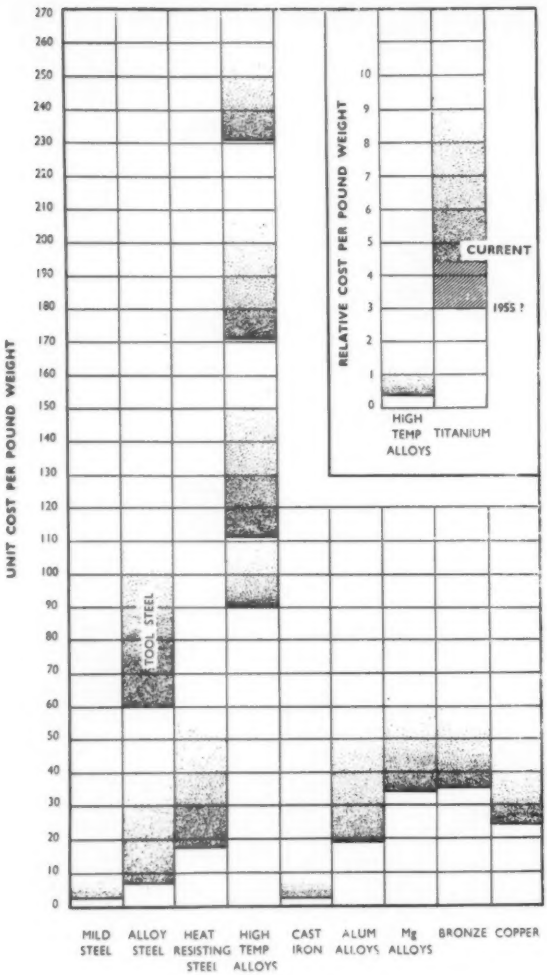
Effective utilisation of material is then the concern not only of the design and manufacturing branches of an organisation, but also of development and research, as well as of those often overlooked departments—repair, reclamation, sales and service. It is proposed to illustrate the influence of these various factors by examples which are taken in the main from the aircraft gas turbine engine. While this might appear to be a too highly specialised product, it does in fact provide us with an excellent standpoint from which to view the problem. The aircraft gas turbine engine makes the best possible use of its material, while its novelty as a type, coupled with extremely rapid developments in performance, coinciding with a greatly expanded programme of production, have led to a study of manufacturing processes and techniques which has enabled the problem to be put into better perspective.

Important conclusions are reached, which show that considerable improvements in overall effectiveness can be obtained by relatively simple means.

Examples of Material Utilisation

Before going on to consider the more fundamental issues, it will be interesting to obtain a rough idea of some typical figures of material utilisation which are being achieved.

After physical properties and general suitability for the purpose, availability and market price of



RELATIVE COSTS OF MATERIALS

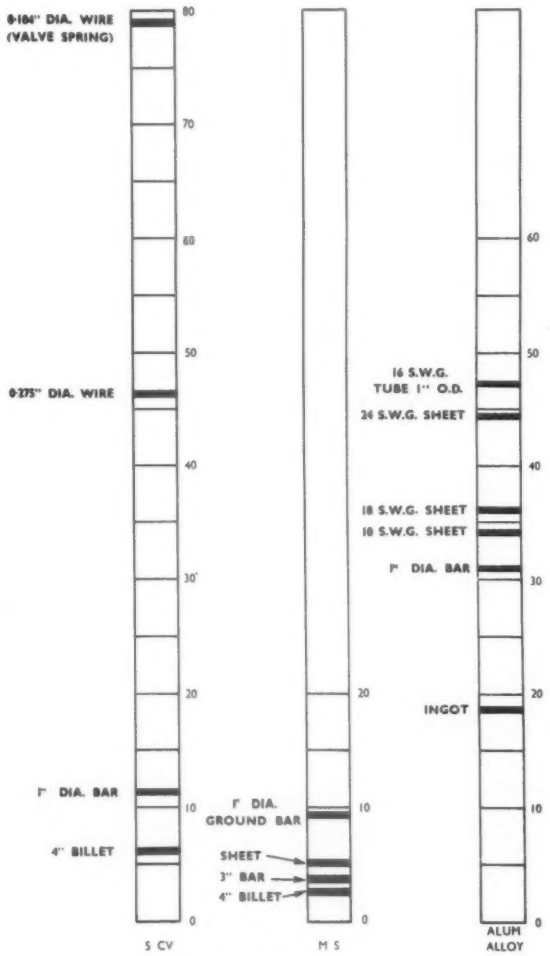
Fig. 1

materials are the measures applied by the designer and the production engineer in making their choice.

Fig. 1 shows diagrammatically the relative costs of the metals used in engineering, in the forms usually employed. These costs can only be approximate, since they vary according to quantity and quality. Leaving aside titanium, it will be seen that the most expensive metals are about 60 times as costly as the cheapest. These costs indicate the overall difficulty of obtaining the ores, of converting them, and manipulating the crude metal into its usable form.

It is not generally appreciated how great are the quantities involved in the production of metals. A blast furnace producing 1,000 tons of pig iron per day, for example, requires at least 2,000 tons of ore, 800 tons of coke, 500 tons of limestone, and 4,000 tons of air. In earlier days, the blast furnace was sited close to the source of supply, but nowadays, the iron ore may have come from Spain, or Australia. Similarly, with aluminium, the bauxite will probably have been mined in British Guiana and converted in Canada. Eight pounds of bauxite are required to produce one pound of bar, and in addition to the thousands of miles of transportation, about eight units of electricity will have been consumed.

The conversion of ingot into usable forms such as bar or sheet involves a mill loss of 40% to 50%. With static castings, the yield from the metal melted may vary between 45% and 65%. In drawing bar into wire-rod there will have been a loss of about 5%, and a further loss of 5% in drawing the rod down to wire. Although the material cropped from the ingot and machined from the billet, and the runners and risers from castings, will go back into the furnace, this recovery may require more or less refining, depending upon the alloys in question. Unfortunately, the higher the alloy, the more difficult usually is the recovery and, in the case of titanium, it is not at the



COST OF MATERIAL BY FORM

Fig. 2

moment possible to reconvert the waste back into the original alloy.

To complete the material picture, Fig. 2 gives an indication of the effect of form on cost. The magnitude of the variation depends largely, of course, upon the alloy and on the quality specified and it is interesting to note, in passing, that those forms from which the highest material utilisation figures are obtained, i.e. wire, sheet, and strip, are the more expensive ones.

Utilisation of the material used in the manufacture of products varies enormously. At the one extreme we have the wire cable and the impact-extruded tooth-paste tube, with figures of 97% and higher. At the other extreme, the figure may be as low as 10% where much machining has had to be carried out. Machinery, which usually comprises an assembly of a greater or lesser number of detail components, will usually have overall values varying from something approaching 40% for the aircraft engine, to 60% or more for mass-produced domestic equipment. It is important to realise that a high figure does not necessarily signify an efficient product. In the case of prime-movers, for example, it is probable that the highest figures for all time were those of Thomas Newcomen's atmospheric engines, and Fig. 3 shows one of 5½ B.H.P.[1]

We have all seen textbook examples of the great savings achieved by changing from a casting to a weldment, from a weldment to a pressing, from a

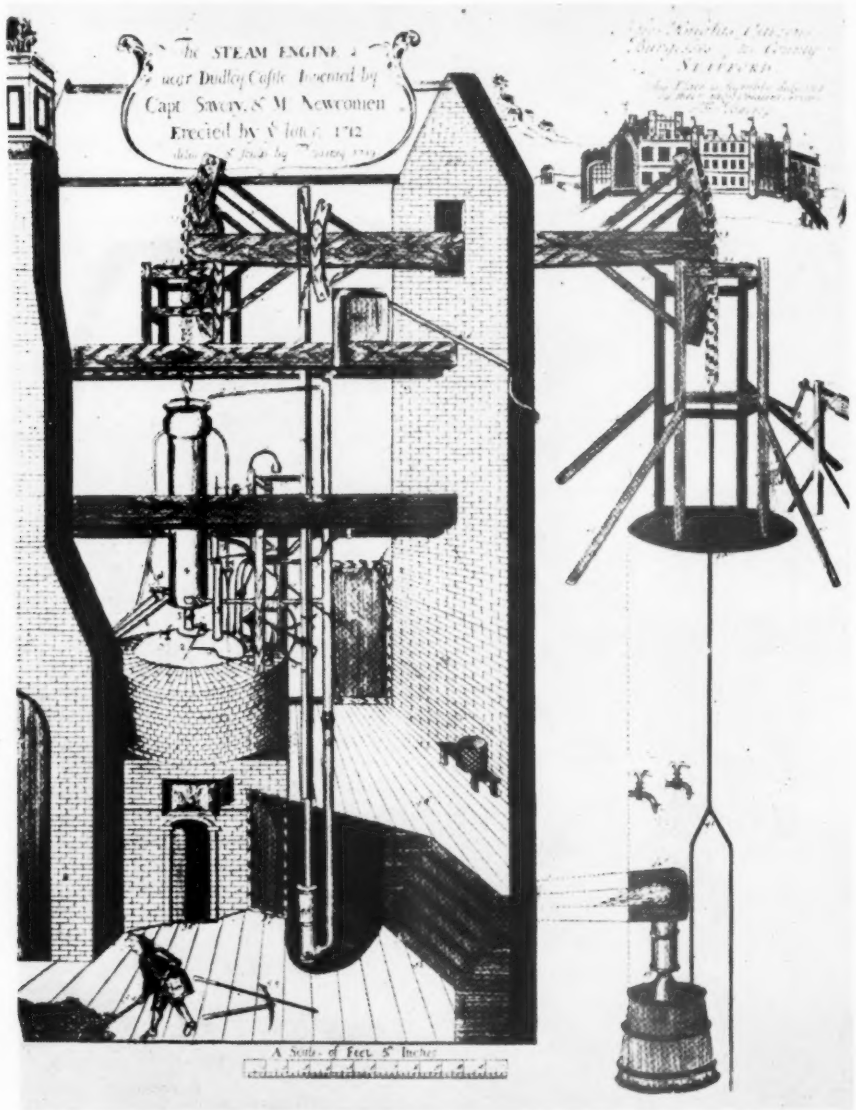


Fig. 3 5½ B.H.P. Newcomen engine

pressing to a forging, from a forging to a casting. While these figures are undoubtedly true for the examples quoted, they often fail to pay any regard to more than the simple facts of cost of material consumed and labour required, and assume that both alternatives are equally suitable for their purpose, and that production equipment, knowledge, skill and technique already exist and are available. The costs incurred in achieving a saving in material need to take account of these factors, and it will not infrequently be found that a reduction in material utilisation may result in a more successful product, i.e. in better effective utilisation of material.

Factors Influencing the Effective Utilisation of Material

Taking as the measure of success the overall value of the product to the customer, we can examine the factors which, to a greater or lesser degree depending upon the application, affect the effective utilisation of material. None of these factors can stand alone; by far the most important one is design. Within the limits laid down by the design of a product for its purpose, the other departments of an organisation play a vital part in its success. Thus the development engineer, the production engineer, whether he be concerned with tooling and planning, or manufacture, and the research worker can, to a greater or lesser extent depending upon the product and its field of application, increase its reliability, and specific performance, whilst reducing its cost and finding means of extending its life by development, by repair and reclamation. The Sales Department ensures that the right product has been chosen for manufacture, and the Service Department helps it to succeed by ensuring that it continues to function to the satisfaction of the customer.

Before coming to the point of main concern to the production engineer, it is proposed to consider briefly the influence of these other departments upon the overall economy of utilisation :-

Design

Here we have two main divisions :-

(i) Fundamental or basic design.
(ii) Detail design.

Each has a considerable influence upon the effectiveness of the material utilisation. Nevertheless, it is as well to point out that a brilliant design can fail if the production engineers do not live up to it, just as many a mediocre design has been made a success by the efforts of the production engineer.

(i) Fundamental Design

This really concerns the aptness-for-purpose of the product.

Many of us will remember the large turnip pocket watches of our grandfathers, and the modern wristwatch is not only a good example of overall material economy, but of greatly increased convenience to the user. So, too, is the miniature camera. In our houses, large reductions have been made in the material content of locks (and keys), bolts and bars, which are at least as effective, and far more

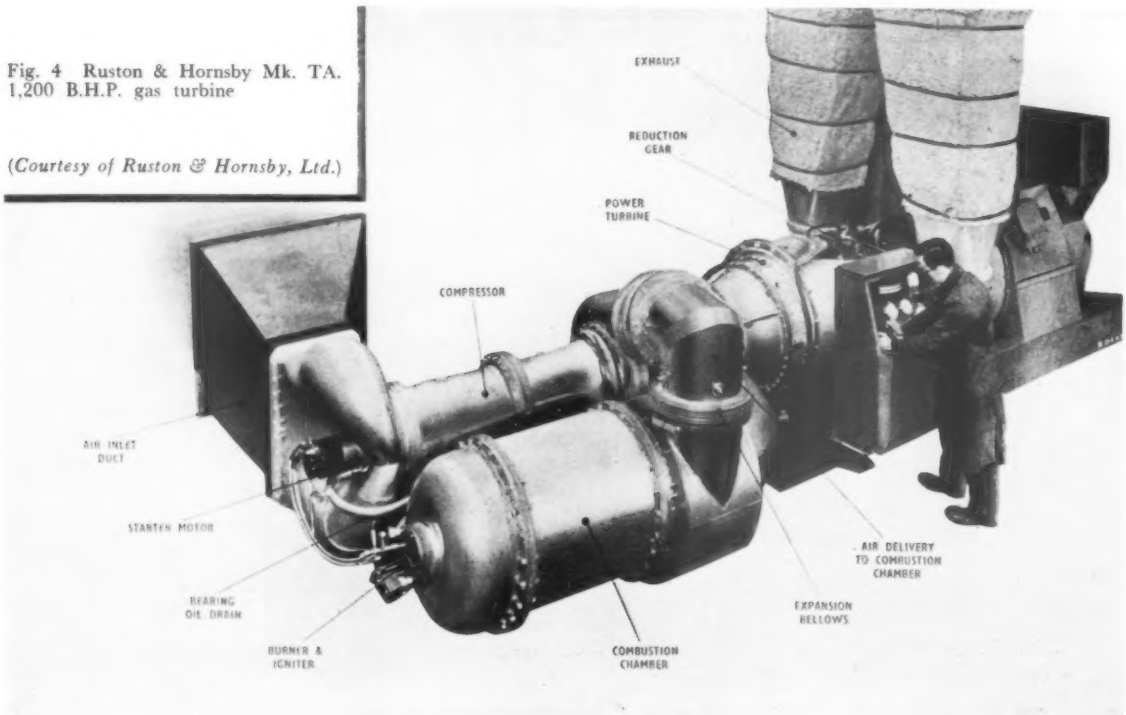


Fig. 4 Ruston & Hornsby Mk. TA. 1,200 B.H.P. gas turbine

(Courtesy of Ruston & Hornsby, Ltd.)

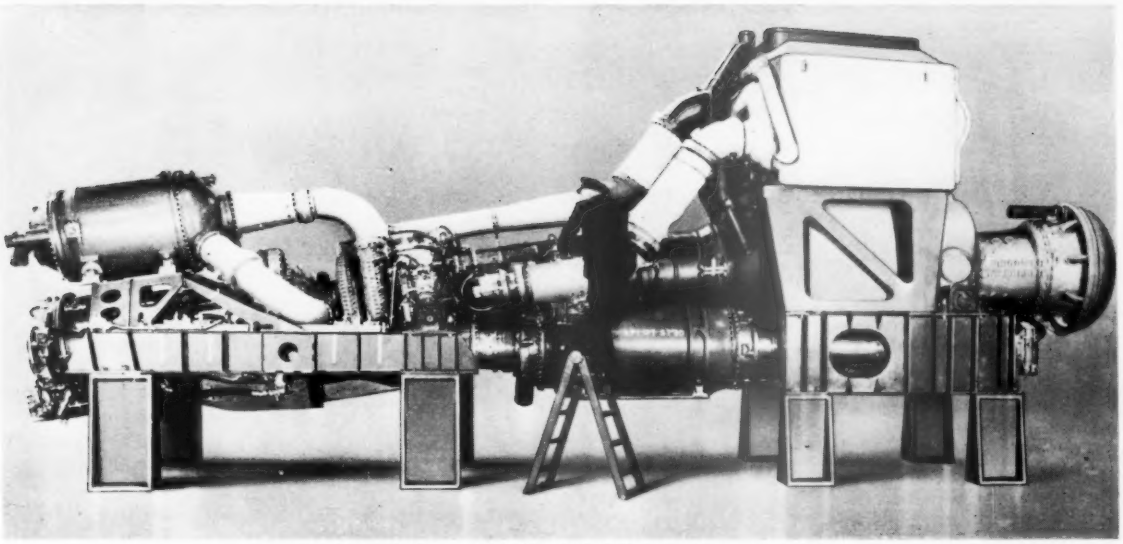


Fig. 5 Rolls-Royce RM.60 5,400 B.H.P. marine gas turbine

aesthetically pleasing, than those still seen in old houses and which, incidentally, have hardly changed since the days of the Romans.

Then, too, we have from long usage become accustomed to seeing large, relatively slow-moving, steam-engines and diesel engines applied to stationary and marine work, and only in the air and on the roads have we seen anything approaching an effort to put the material of prime movers to really effective use. And now in these fields the gas turbine is providing a striking example of the influence of fundamental design. Whether it is applied to air, marine, or stationary duties, this type of engine produces power from one-third to one-seventh the weight of the lightest equivalent power unit.

Thus, in the stationary field, the Ruston and Hornsby Mark T.A. gas turbine engine (Fig. 4) has a continuous rating of 1,200 B.H.P. for a basic weight of 12,300 lb., which is stated to be one-third the weight of the best equivalent engine. In addition, there are other great savings in the installation, since no heavy foundation is required, and no cooling system, no water softeners, no coal bunkers, and no disposal plant.

In the marine field, the Rolls-Royce Marine Gas Turbine RM.60 (Fig. 5) produces 5,400 B.H.P. for 29,000 lb. weight. As installed in the "Grey Goose" (Fig. 6), two of these engines displaced two 4,000 B.H.P. steam turbines which were the lightest steam power units of their type ever produced, but which weighed twice as much. In addition, the RM.60 engines require 25% less space and give 30% lower specific fuel consumption.

The Avon Mk.1 engine (Fig. 7) has a static sea level thrust rating of 6,500 to 7,500 lb., depending upon the model. It weighs, complete with its jet pipe, 2,710 lb. and it is used to power the Comet II aircraft (Fig. 8). To propel this aircraft through the

Fig. 6 "Grey Goose"

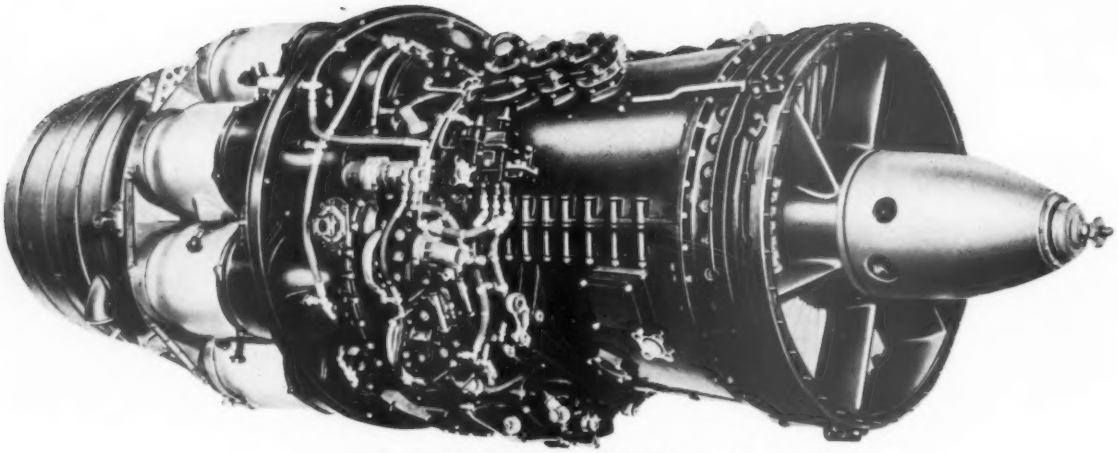


Fig. 7 Rolls-Royce Avon Mk. I jet engine

air at its continuous cruising speed of 500 m.p.h. at 40,000 feet, requires about 10,000 H.P., or 2,500 H.P. from each engine. The highly supercharged Merlin 724 piston engine weighs dry 2,400 lb. but with radiator and coolant, oil cooler, propeller and exhaust system, etc., i.e. as a " going engine ", (Fig. 9), about 3,600 lb. At 40,000 feet it could deliver 450 H.P. or, effectively, assuming 80% propeller efficiency, 360 H.P. Admittedly the engine was not designed to operate at this altitude, but it is obvious that the Avon engine is making far better use of its material. And if we try to visualise what the Comet II would look like if in some nightmare its designer tried to power it with Merlins, we would get something like the apparition shown in Fig. 10. So we see here a striking example of aptness-for-purpose, since by reason of its high power at altitude, its low weight, and small frontal area, the Avon engine enables the aircraft designer to achieve what would otherwise be impossible.

At the other end of the horse-power scale, we have the small French gas turbines, the Blackburn-Turbomeca Artouste I and II, giving continuous powers of 226 B.H.P. and 325 B.H.P. for 183 and 200 lb. weight respectively.

While in these examples there are great savings as compared with the equivalent power units, there exist also between themselves wide differences of material utilisation, as shown by the weight per horsepower figures. It is regretted that it is not possible to deal more fully with the fascinating subject of the aptness-for-purpose of these engines, but we may turn for a moment to the reciprocating oil engine and see what might be achieved here by a different basic conception.

If the normally accepted solutions are examined critically, it is difficult to see why the typical stationary and marine diesel engines are such huge heavy monsters. The reason is most probably that given by Sir Harry Ricardo: " One cannot escape the suspicion that the use of very large diesel engines at sea is due, as Sir Alfred Ewing suggested recently, ' rather to the taste and fancy of some dominating personality than to a careful weighing of arguments such as appeal to engineers ' ".2

In 1931 and again in 1933,3 Sir Harry strongly pressed the advantages of using a multiplicity of small high speed diesel engines instead of the large ones which were and are still the prevailing fashion. He showed that the weight per horsepower fell appreciably as engine speed rose and engine size was reduced, and though the *cost per ton* of the high-speed engine might be treble that of the slower engine, the resulting *cost per horsepower* of the high speed engine was only about one-quarter that of the slow one.

Fig. 8 De Havilland " Comet II " airliner

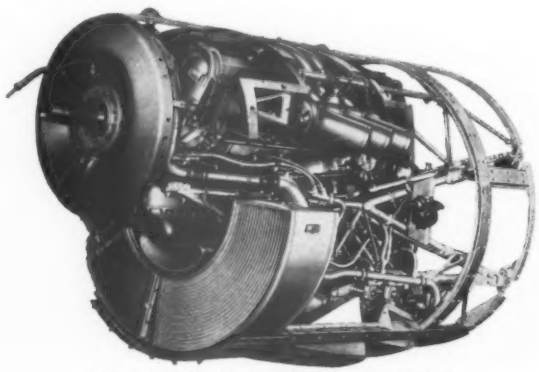


Fig. 9 Rolls-Royce Merlin power plant

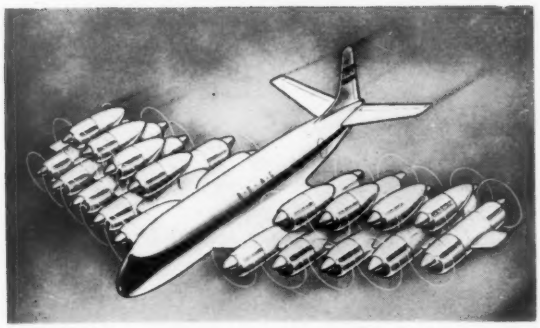


Fig. 10 Hypothetical piston-engined high altitude airliner

Further interesting examples have been given recently of the reductions in weight and real cost of typical motor cars, amounting to 25% in twenty years. In addition, by the adoption of a V-arrangement of cylinders for the engine, a 20% saving in weight of power plant is possible.[4]

(ii) Detail Design

Within the bounds laid down by the basic design, the designer is able to exert a considerable influence upon the product. He will give due weight to a number of considerations having an important bearing upon the way in which the material is used. These include some or all of the following, depending upon the type of thing under consideration :-

(a) Purpose and function of product
(b) Performance
(c) Cost
(d) Weight
(e) Appearance
(f) Ultimate life
(g) Running cost
(h) Overhaul cost
(i) Scale of production
(j) Availability of desirable materials
(k) Manufacturing facilities available.

The relative importance of these factors will vary enormously with the type of product, and with the rate and scale of production anticipated for it. For example, a casting left rough will give a higher material utilisation figure than a machined-all-over part, but if it entails lower safe working stresses, and increased weight, the net result might well be worse. It is only by analysing all the factors that the best result can be obtained, and here a certain amount of give and take by both designer and production engineer is essential for success.

This interplay of influences is only effective, however, if the two parties are properly matched. Much has been heard of the American way where the production engineer has too often overwhelmed the designer, with the result that while there might be overall cheapness and high rate of output, there is inflexibility and a tardiness to take advantage of developments in design thinking. In this country excellent results have been obtained by designers forcing the pace, but this succeeds only when they are matched by production engineers of comparable ability, and of sufficient strength to apply the curb when it becomes absolutely necessary.

Mention has already been made of the advantages of small light oil engines. The aircraft engine provides an even more striking example. In order to obtain the highest performance with minimum weight, the aircraft engine designer works his engine at the highest temperatures feasible with available materials and he works those materials at the highest possible stresses. This means that expensive special alloys are specified where necessary, and there is no hesitation in calling for what in other fields might seem to be an excessive amount of machining. Yet the net result is that the prime cost per brake horsepower at continuous rating is appreciably lower, for the aircraft engine of the type under review, than for any other type of engine in its power class. This is due partly to the quantities produced, but largely to the fact that the increased cost of material and of the greater amount of machining are more than compensated by the increased amount of work done by the material.

Interesting light is thrown on this by a comparison of the Merlin 724 and the Avon Mk.I engines. In the bare engines, the overall material utilisation figures are about the same, but the average cost per pound of the raw material used for the Avon is roughly double that of the Merlin. The manufacturing man-hours per pound are much higher in the case of the Avon, due to the difficult shapes and still more to the difficult materials employed. Yet the cost per continuous horsepower of the Avon Mk.I, even at its present early stage of development, is roughly half that of the Merlin under equivalent conditions, and this ignores the additional cost of the airscrew, radiators, cowling, etc., which are necessary to convert the Merlin into a similar "going engine".

With all this, the aircraft engine designer has to keep a careful eye upon the strategic content of his alloys, which may contain high percentages of nickel,

Fig. 11 Rolls-Royce Nene turbine disc

Fig. 12 Components common to Rolls-Royce "B" range of engines

chromium, molybdenum, cobalt, etc. It is interesting to note here that in addition to being technically well ahead, British aircraft gas turbines employ far less of the strategic alloys than do the American engines, and this is another example of effective utilisation of material.

An example of this is seen in the case of the Nene turbine disc (Fig. 11). This was made originally from a forging weighing 148 lb., in a strategic alloy. By applying air cooling to the disc, it was possible to use instead a much lower alloy, and at the same time to reduce the weight of the finished disc by 24 lb. The net saving in cost of the forging was £89. Incidentally, this disc transmits 10,000 (ten thousand) H.P.

Where the overriding considerations of performance and reliability permit, the designer can help greatly by making provision for easy replacement of vulnerable parts. By keeping the number of different parts to a minimum, there are savings at every stage, but in addition there can be too an appreciable saving in material, through reduced discards as well as reduced holdings of raw material and spares stocks. The Rolls-Royce 'B' series of rationalised engines provides a good example here, Fig. 12 showing the parts which are common throughout the range.

Whatever the product, the designer can play a great part by refraining from calling unnecessarily for materials which are difficult to obtain; for tolerances requiring new machines or inspection equipment, or leading to a higher rejection rate; for modifications involving wastage of material and jigs and fixtures and tools.

DEVELOPMENT

The Development Department is of particular importance in the case of machines and prime movers. In these fields the function of the development engineer is to test the product to discover its weaknesses and by eliminating them, to increase its reliability, its life and its specific performance. To some extent these are interchangeable, but an improvement in any of them is usually equivalent to "better value for money" in the material used. Quite often development will lead to the strengthening of a component by the addition of material or by the use of a stronger and more highly alloyed and more expensive material, or by more machining or other process to improve the finish. The increase in life or duty consequent upon this, however, will almost invariably far outweigh the increased cost incurred.

Work which is going on all the time on the performance of compressors and turbines, and on combustion efficiency, for example, has a considerable effect upon the specific performance and economy of an engine, usually for a negligible difference in material weight.

The prototype of development engineers was Richard Trevithick, who in 1804 broke away from the tradition of the heavy and cumbrous atmospheric engines of Boulton and Watt, and introduced high pressure steam.

He had to develop a boiler to withstand pressures of up to 150 p.s.i., and the Cornish and Lancashire boilers still follow closely his original design. In one leap he multiplied the power output of a given size of engine several times, and not only made railway locomotion possible, but pioneered it as well. This work caused about as big a stir as that of the gas turbine engine today.

Returning to the aircraft engine, the overhaul life of the civil Merlin 724 engine was raised by development from 600 hours to 1,250 hours, for an increase in weight of only 70 lb., and only a small increase in cost. This engine is one of the latest of a long line of basically similar ones of 27 litres capacity which started in the last War as a 1,000 B.H.P. engine, and finished at nearly 2,000 B.H.P., again largely through development.

Another good example of development is found in the nimonic alloys which are used for turbine blades. Fig. 13 shows how during the past few years the strength at temperature has been increased to give an effective rise in operating temperature of about 60°C, which enables the thrust per pound of air consumed to be increased by 16% for the same weight of engine.

As applied to the motor car, development has traditionally taken the form of speed and reliability trials, and the increased activity of recent years betokens a healthy state of affairs in this industry. As users, we have benefited in obtaining, for far lower cost, performances from ordinary saloon cars which were formerly only to be obtained from expensive sports cars.

RESEARCH

It is unfortunate that, in this country at least, there exists a good deal of misunderstanding of the true meaning and function of research, as much amongst research workers themselves as in the minds of practical engineers. This has led to confusion and overlapping, doubt and suspicion and some lack of co-operation.

The situation has been admirably clarified recently by Mr. O. W. Humphreys, Director of the G.E.C. Research Laboratories.[5] He defines research as the search for new knowledge, development as the application of existing knowledge. Research can be subdivided into fundamental, exploratory, basic and objective categories. These need not concern us further here, except to point out that for the urgent solution of his day-to-day problems, the production engineer must depend primarily upon the efforts of himself and his development staff.

Some researchers have tended to weaken the faith of engineers by trying to provide quick answers to practical problems when they would have been better occupied in seeking fundamental solutions. It is not appreciated as it should be how narrow is in fact the gap between the production engineer and the fundamental research worker, and efforts to fill this gap by so-called researchers is tending to result in a good deal of redundancy.

Much of the most successful research has been carried out by men of practical outlook. It is interesting to look for a moment at the work of the past few decades, which has led to enormous improvements in material utilisation.

For instance, it is about one hundred years since the phenomenon of fatigue was first recognised by Robert Stephenson and others.

Then, in 1871, Wohler published his work on endurance tests under reversals of stress. But it required the impetus of the First World War to bring about an intensification of research effort, and the

Developments in Nimonic Heat Resisting Alloys

Alloy	Temperature for fracture in 100 hours at X tons/sq. in.	Corresponding increase in thermal efficiency	Corresponding increase in thrust per pound of air consumed
80A	880C	—	—
90	910C	2.6%	8%
95	940C	4%	16%

Courtesy of Hy. Wiggin.

Fig. 13 Developments in Nimonic Alloys

practical application of it to design. Other allied researches were made on the stress concentration due to sharp corners and oil holes, and on the effects of surface finish, notably by Professor Coker, Dr. A. A. Griffith, and others. Most of this work was inspired by the needs of the aircraft engine, and a good deal of it was in fact carried out under the auspices of the Aeronautical Research Committee. If we look back at text books of engineering design of thirty to forty years ago, there is no mention at all of the importance of adequate fillet radii, good surface finish, and freedom from cracks, and illustrations of engines show a frightening lack of any sort of radius at shoulders in keyways, etc. In fact, even more recently during his apprenticeship, the writer was once taken seriously to task by a foreman because he had not removed the radii from the root of a keyway, and produced a fitting key with dead sharp edges!

This work, by enabling the designer to work with a more accurate knowledge of stresses, and hence with a lower factor of safety, has led to a lightening of structures generally, with, in the aggregate, an enormous saving in material. Of even greater importance has been the very great increase in reliability which has come about in many fields—machine tools, presses, motor cars, railway wagons, aircraft engines, and so on, which indirectly has meant again better material utilisation.

Concurrently, important researches have been made, by applied mathematicians and engineers, into vibrations of structures. During our time, the problems of torsional vibration of crankshafts, the surging of valve springs, the vibration of ships' gearing, and of bridges, have been studied and solved. Aircraft wing flutter, and the vibration of gas turbine compressor blades, are both being worked upon actively. Without this work, the avoidance of serious trouble is largely fortuitous, and when it occurs, it can often only be remedied at the expense of heavier sections or more costly materials.

In the metallurgical field, it is perhaps more obvious how much we owe to research, and again how recent it all is. The first alloy steel (Hadfield's manganese steel) was invented in 1882, but was not in general use until the end of the century. Stainless steel was invented by Brearley only in 1913. The R.R. series of aluminium alloys was developed during the 1930's and the series is still being actively extended and improved. Magnesium alloys have come into widespread use in aircraft engines even more recently and outstanding improvements have been made here too. Now we have titanium, which by virtue of its properties will obviously be taking its place in engines at no distant date. Other spectacular developments which have been the sole means by which it has been possible to progress beyond prevailing limitations have been special steels, and stellite and Brightray and sodium cooling for exhaust valves, and the high temperature (e.g. "Nimonic") alloys for turbine blades.

The applied research on machining is too well known to need comment. As the metallurgist comes along with the tougher materials to meet the increasing demands of the designer, this work continues to provide the machine-shop man with better tools and better methods. Examples of what is going on are to be seen in carbide cutters, high speed machining, hot machining, better lubricants, better cooling by CO_2 and strong jets of directed coolant, machining by electric spark, sparkanodic, and supersonic methods, and so on.

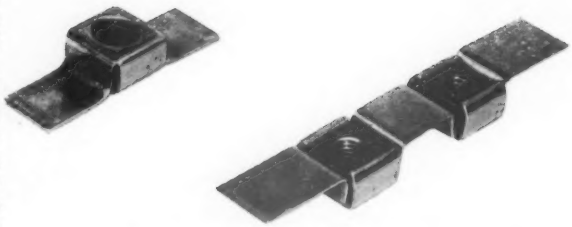


Fig. 14 Automobile body cage nuts.
(Courtesy of Mark Perks, Ltd.)

MANUFACTURE

Here we come to the section of primary interest to the production engineer. Every aspect of production management and engineering is concerned, and while these cannot have the same influence as design upon material utilisation, they play a very big part in the ultimate cost of the product. While the high performance, the light weight, and the reliability of the Avon engine, for example, are due in the main to the efforts of the design, development, and research departments, the relatively low cost is due in the main to the manufacturing side, which has made a most important contribution to the other aspects too, by finding ways of forming and fabricating materials normally considered to be "impossible".

Although the designer may be setting the pace, it is the production engineer who maintains it, as much today as 180 years ago, when John Wilkinson's boring mill allowed steam engine development to go forward. It may be remembered that he bored a 50″ diameter cylinder to a tolerance equal to the thickness of an old shilling, and later improved his technique so that the tolerance on a 72″ bore was not greater than the thickness of a thin sixpence[1].

Rate and Scale of Production

Considerable responsibility rests upon the production engineer and management alike, to ensure that the choice of machinery and methods, and the type of tooling, are properly matched to the scale of production. There has of late been a good deal of misunderstanding here, due in the main to a too loose use of the terms "increased production", "large scale production" and "mass-production". As a consequence, the special techniques of design and tooling and production which have been developed to meet

the needs of the motor car and ancillary industries, for example, are too often held up as models for all to copy.

The greater part of British industry is in fact not employed on mass-production at all, which is perhaps a good thing since it gives full play to our genius for extemporisation and flexibility. This has an important and perhaps somewhat unexpected effect upon material utilisation in minimising scrap and wasted effort due to modifications. For instance, in the case of large bomber aircraft, during the War, the productive man-hours per pound of aircraft were almost identical for similar British and American machines. As modifications became necessary to overcome defects, or to meet tactical or strategic needs, they were introduced quickly and smoothly into the British aircraft, without interrupting the production flow or reducing the output. In the States, the planned "mass-production" lines were so rigid that the factories had to go on producing obsolete aircraft which were then shipped hundreds of miles away to Modification Centres, where the new parts were fitted, and the old thrown away.

At the opposite end of the scale, a free and unfettered outlook, capable of turning away from the orthodox and getting right down to fundamentals, can save enormously by resisting the temptation to spend unnecessarily on equipment of high capacity, and to use commonsense instead. The double cage-nut shown in Fig. 14 is a good example. Planned along textbook lines, this item, which is required in tens of thousands, would be made from steel strip, on a battery of roll feed and dial feed presses costing about £3,600, with tools costing about £500, and at a rate of say 40 per minute[6]. It is actually produced at the same rate, on a battery of four fly presses costing say £140, with tools costing about £30. By using off-cuts, which would be impossible on the automatic machines, the selling price is considerably below that of the fully-tooled job.

It is not recommended that all modern presses should be discarded in favour of fly-presses—there would not be enough scrap metal to go round anyway! But this example does illustrate the danger of assuming automatically that orthodox planning and high speed equipment are essential for high rates of output. Hard work also plays its part. It shows too that the production engineer need not despair when an unsympathetic management refuses to sanction further capital expenditure!

Especially where quantities are not so great, but in the mass-production field as well, the development of methods requiring less tooling, or less in the way of special equipment, can result in considerable savings in capital expenditure. This need for flexibility of equipment was stressed by Mr. Puckey* in his Presidential Address to the Institution, and it is of particular importance where competition is intense and designs are changing correspondingly rapidly. Perhaps the greatest scope for improved flexibility is in the sheet metal field, where, following the lead of the motor body manufacturers, high tooling costs have come to be regarded as commonplace and, in consequence, inevitable and acceptable. The possibilities here will be dealt with later.

Again, particularly in the aircraft engine field, the planning and tooling engineer must pay careful regard to the probable stability of the design. In these days of rapid developments in new fields, modifications and the introduction of new models are the order of the day. During one year of the last War, for instance, 22 different types of piston engine were produced at Derby, whilst throughout the manufacturing life of each type of engine, the number of modifications averages between 60 and 100 per annum. This rapid multiplying of engine types in current production, and the continuous changing of design, coupled with the scale of production, makes aircraft engine manufacture much more a matter of large-scale jobbing than of mass-production, and here is another reason why flexible and adaptable methods of manufacture are essential. It has, too, an important influence on the material utilisation figures achieved. Here the planning engineer is often faced with a difficult choice. On the one hand he is conscious of the need to improve the material utilisation, in order to reduce the amount of metal in the pipeline, but often such reductions can only be obtained at the cost of reduced flexibility of method, and reduced availability of supplies.

In this connection a speech by Mr. Gordon McGregor, President of Trans-Canada Airlines, at the recent dinner of the Society of British Aircraft Constructors, is worth quoting. Dealing with the success of the British aircraft industry in overseas markets for civil aircraft he said : -

"Manpower is such an expensive commodity in the United States that it is becoming increasingly necessary to go to any lengths to conserve it . . . . . This condition is driving the American manufacturer into fantastically large investments in tooling. Where vast production quantities are involved, no harm is done . . . (but) these advantages unhappily vanish where the production of large civil aircraft is involved. The total number of any one type is unlikely

Fig. 15 Bristol radial engine master and articulated rods. *(Courtesy of Bristol Aeroplane Co. Ltd.)*

* Now Sir Walter Puckey.

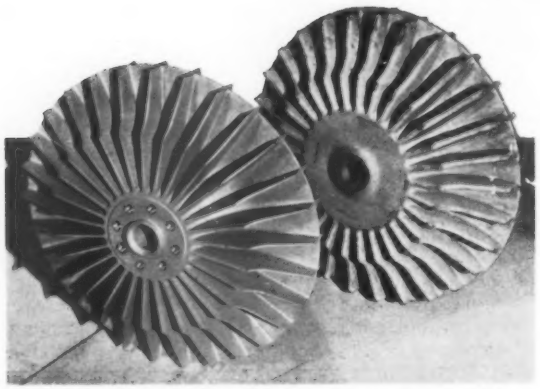


Fig. 16 Rolls-Royce Derwent compressor rotor

to exceed 200 or 300; yet, having been driven into a massive investment in tooling, the manufacturer finds it economically difficult to abandon a design in favour of one more advanced . . . On the other hand, the lower cost of manpower in this country makes possible its greater use, with a consequently smaller investment in the tooling specific to any one aircraft type. A manufacturer in Great Britain could undertake the production of a comparatively small number of any one type, without risking the financial loss of a large amount of scrapped tooling."

It is well to bear these remarks in mind when one is approached by an American salesman trying to recover the costs of developing his wonder-machine by selling some abroad!

Choice of Method

Since the highest possible performance must be obtained from every component of the aircraft engine, the form which is best suited to the conditions of duty, e.g. forging, casting, or fabrication, must be employed in each case.

No manufacturing process which offers an advantage in any way can be ignored, and in consequence we find that most available processes are employed to a greater or lesser degree. In some cases the methods used may appear to be expensive by other standards, but they are only adopted when it has been confirmed that they do in fact produce the best component at the lowest cost.

We find then in the aircraft engine, forgings and drop stampings in high tensile and in high temperature alloy steels, machined all over; precision die-forged blades in a wide variety of materials, machined only on the roots; sand castings, die castings, centri-castings, centri-spinnings, shell mouldings, and precision castings in light alloy, iron, steel and high temperature alloys; hot extrusion, impact extrusions, pressings, spinnings and fabrications in light alloy, alloy steel, stainless steel and high temperature alloys; brazings by torch, salt-bath, induction and furnace in a variety of alloys; weldments by arc, shielded inert gas metallic arc, torch, spot, stitch, seam and flash butt.

Such a great diversity is only possible in a fairly large organisation employed on a high quality product where performance is the primary concern. The task of the production engineer is to ensure that each process is employed efficiently, in the right application, and on the appropriate scale. An advantage of the wide variety of choice is that the thorough understanding of the scope of each one which it is essential to have makes it possible to view them dispassionately, and to select the best without favouritism. Moreover, the apparent lavishness of choice provides its own incentive to plan and produce efficiently, as otherwise it would become an intolerable on-cost.

In fact, the wide variety does not so much entail expensive equipment as a broad knowledge of skills and techniques. In all cases each process is carefully scrutinised from the point of view of its applicability to the job, and especially to the scale of production and flexibility and speed of introduction permitted by the method. These last points are of the greatest importance in the aero-engine field, where often in the last War the speed with which a modification could be introduced played a vital part in a particular tactical or strategic phase.

The claims put forward for any new process are viewed most critically, and in many cases the chief value of a new process has been to provide a spur to a fresh analysis of the shortcomings of the existing method, which it has been found possible to improve beyond the standard of the new one, thus avoiding the delays and expense which would have been incurred by re-equipping and learning. It is especially important to ensure that any new method shall not restrict the scope for rapid expansion of production in an emergency.

Perhaps because the aircraft engine manufacturer has had to become a master of all trades, he is well qualified to comment on the questions which are so

Fig. 17 Rolls-Royce Dart turbine blade

much occupying management and production engineers today. Spurred on by the needs of the engine, he has in several vital instances been compelled to adopt processes which have normally been operated by specialist trades, and to develop them, in an extremely short space of time, to a pitch which the expert has stated was impossible. This has been achieved by a refusal to accept statements without proof, by a straightforward approach to the problem.

In fairness to some members of the specialist trades, it must be said that in the first instance the new developments, as of precision forging and precision casting, could only be justified when applied to expensive materials, but even then it has required the uninhibited approach of the enthusiastic amateur to achieve success. This will be best illustrated by taking a few examples, and in order to put the matter into correct perspective it is appropriate to mention here that over 30% of the finished engine is made from forgings, 5% from bar, over 40% from castings, and 10% from sheet and tube. The overall utilisation figures average 22% for forgings, 44% for castings, and 50% for sheet metal parts.

Forging

The need for absolute reliability in the highly stressed moving parts of the aircraft engine has meant that crankshafts, connecting rods, pistons, valves, and gears have for many years been machined from forgings whatever the type and make of engine. The chief influence of the aircraft engine industry here has been due to its insistence upon absolute cleanliness of the metal, accurately controlled forging to give the most appropriate grain flow, and withal the development of materials of ever-increasing strength, which has intensified considerably the task. For instance, ultimate strengths of 65/75 tons/sq. in. for nitriding crankshaft steels, 100 tons/sq. in. for case-hardening steels for radial engine connecting rods, and 85 tons/sq. in. for case-hardening gear steels, were normal for the engines of the last War. Machining and finishing all over were of course essential, as much to provide the highest possible resistance to fatigue as to reduce weight to a minimum. For example, the radial engine master rod shown in Fig. 15 weighs 9¼ lb. and has been machined from a forging in 100-ton case-hardening steel weighing 42 lb., a material utilisation of 22%. This figure needs to be regarded in light of the fact that the rod is transmitting over 1,000 B.H.P.

The gas turbine engine has forged shafts and turbine and compressor discs which follow orthodox lines. Fig. 16 shows the light alloy forging and the finished compressor rotor of the Derwent engine. The material utilisation is 48%. In the axial engine the turbine and compressor blades present a special set of problems, due to their shape and the materials from which they are made. The difficulties of producing accurately thin aerofoil sections, having varying degrees of camber and twist according to the still limited but growing experience of design and performance, in light alloys, stainless steels and high temperature alloys, have naturally led to a number of different solutions, both in this country and in the United States.

With blade shapes and methods still in a somewhat fluid state, it is perhaps a little too early to be definite about the ideal solution, and since there is in addition a wide variety of design practice in the form of root fixing, it is possible that more than one method may persist. In the author's personal opinion, however, there is little doubt that precision forging of the aerofoil will always play a big part.

This is one of the cases where the engine manufacturer has had to master a trade and point the way. This is exemplified by the turbine blade of the Dart engine (Fig. 17), which is forged to size on the aerofoil and on the platforms, so that these areas require no machining other than the radiusing of the leading and trailing edges after the flash has been clipped off. Those who are familiar with the difficulties of machining modern turbine blade materials will appreciate how much time and trouble have been avoided. It has been necessary to develop speedy methods of producing forging dies, with the result that the die cost per blade is certainly competitive with the cost of the cutters consumed in the alternative machining process.

Precision forging of less difficult shapes and in less difficult materials and to somewhat wider tolerances is, of course, well established and good figures of material utilisation are obtained in a large variety of products of fairly small size, such as automobile engine valves, steering mechanism details, and so on.

Losses occur between bar and forging due to the flash, scale, tonghold, test piece in the case of aircraft engine parts, and parting or shearing. These may amount to 30% to 40% according to shape.

Another interesting example of progress in the wrought materials field is shown in the adoption of the Ugine Sejournet process for the extrusion of sections in stainless and alloy steels. The gas turbine engine, being essentially cylindrical, employs a fair number of circular flanges, which are welded on to casings. These flanges have been turned from cylindrical forged or cast rings, with a material utilisation, of fairly expensive metal, of about 22%. By making rings of extruded section, coiled and flash-butt welded, the overall utilisation has

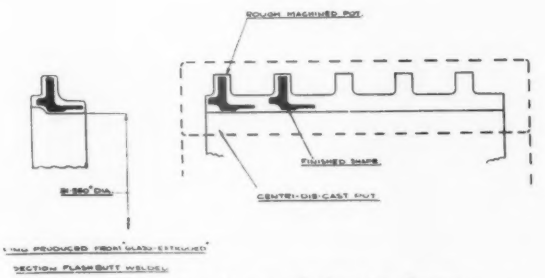


Fig. 18 Manufacture of rings for flanges.
(Courtesy of Chesterfield Tube Co. Ltd.)

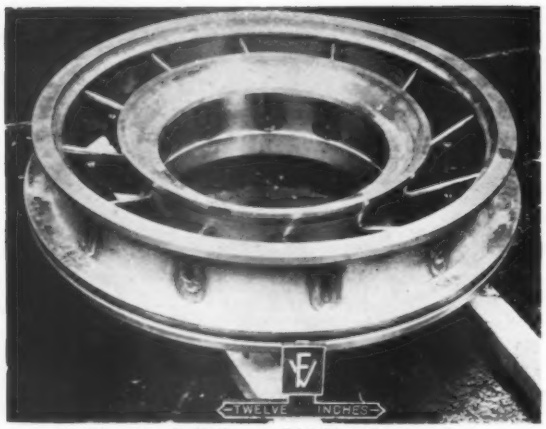


Fig. 19 Rolls-Royce RM.60 exhaust unit
(Courtesy of Firth-Vickers, Ltd.)

been increased to about 36%, and there has been a reduction in overall cost (see Fig. 18).

The extrusion process too holds out considerable promise of greatly improved yields from ingot to usable form, a development of particular value in the case of the expensive strategic materials.

Mention must be made, too, of rolled and drawn shapes, where the utilisation can be high. Aerofoil sections can be rolled in lengths of stainless steel, with a loss of only 4% from bar to blade section. Complex shapes can be cold-rolled to a high degree of accuracy, with a loss of from 3% to 7%.[7] The only additional loss in applying these forms to compressor blades, gun trigger mechanisms, and the like, is that incurred during parting-off.

Casting

Intrinsically, the casting method ought to give us by far the cheapest metallic shapes, since moulding enables almost any form to be produced, and the scrap material, from runners and risers, takes the shortest possible cut straight back into the furnace. That castings are not in general use for highly stressed moving parts is due, in the main, to a widespread distrust which can usually be traced back to some unfortunate experience, such as that never-to-be-forgotten occasion when as a child the author dropped his new toy revolver, and the casting shattered. Still referring to the aircraft engine, in the larger sizes of static parts, castings cannot always be produced to the dimensional accuracy and thinness which is dictated by the insistence upon lightness. They find their widest application, therefore, in light alloy static casings, where the effect of dimensional errors is not so great; in iron castings which can be machined all over; and to precision castings in high temperature alloys for smaller static parts such as nozzle guide vanes.

The economic advantages of being able to use as-cast parts for other components than these are so great, that it is not surprising to see in the foundry industry today greater activity than for a long time past. We have seen during recent years the development of lost wax (e.g. Austenal and Trucast) and frozen mercury investment casting, shell moulding, the Shaw process, plaster moulding, permanent mould casting of ferrous alloys, and so on. In the main, however, these have been mould-making rather than founding methods and, while they have undoubtedly led to improvements in accuracy and cost, improvements in the quality of the castings have in most cases been incidental. Fortunately, the need for fundamental work on the metallurgical and founding sides is being appreciated more and more widely, and it is pleasing to note that considerable improvements have already been obtained, whilst others are pending, both as regards the accuracy of bigger castings, and the physical properties and reliability of smaller ones.

The argument usually adduced against castings is that they are unreliable because of the difficulty of ensuring freedom from undesirable inclusions, porosity due to shrinkage and gas, coarse structure, hard and brittle spots, shrinkage cracks, and so on. One of the main functions of forging is, in fact, to minimise the effect of such defects in the as-cast ingot.

By systematic attack upon the basic causes of these defects, considerable advances are being made. The Qualcast Permanent Mould process, for example, is producing castings completely free from porosity, with fine grain and with a mirror finish if required. Cast crankshafts for motor car engines and compressors, which were first mooted in 19128, have been commonplace for the past fifteen years or so as sand castings by the same company, by Jessops, and others. The Ford Motor Company has cast its crankshafts for years, more recently by the shell process, and camshafts and valves as well.

Fig. 20 Lost wax bronze casting, .100" thick, *circa* 400 B.C.

Porosity and control of grain size are being tackled in a variety of ways, as instanced by the cast milling cutters of B.S.A., whose cast steel forging dies are also coming into general use. Vacuum casting, controlled rate of freezing, as by the Parlanti and other methods, and the development of high duty heat resisting alloys specially adapted for casting are all playing their part. In the United States, cast turbine blades are being used in some aircraft engines.

Where operating temperatures preclude the use of light alloys, iron and nickel-chrome steel castings are used, and are machined all over to obtain consistent thicknesses. Where it is not possible, by reason of the shape, to machine all over, recourse may be had to a composite construction, as shown applied to the exhaust casing of the Rolls-Royce RM.60 engine (Fig. 19). Here two centri-castings are used, machined to section on one side only, before having the radial members welded in. It is encouraging that in one foundry at least, making static castings, tolerances of $\pm$.005″ on as-cast diameters of 30″ or more, are within sight of achievement. Further development is urgently needed to enable castings to be produced to the desired thickness, without machining. It is a sobering thought that this will only bring us to the stage reached by the ancient Greeks, who were able to cast, by the lost-wax process, bronze statues such as the six-foot high one shown in Fig. 20, weighing only 100 lb., and averaging less than .100″ in thickness[9]. Earlier Egyptian castings were even thinner.

In castings such as those just postulated, there is little doubt that the new spheroidal graphite cast iron will play a big part. With up to double the strength of ordinary cast iron, and much greater ductility and greater stiffness, it will help a great deal to keep material weight down.

Fig. 21 Structural stainless steel castings. By kind permission of the Director of Naval Construction, Admiralty. *(Courtesy of Firth-Vickers, Ltd.)*

There has during the past few years been a tendency to replace cast structures by weldments. Cases have been made out showing appreciable savings in weight, and reduced cost due to no pattern being required. These are perfectly true when comparing steel with cast iron, and when considering one-offs, but Fig. 21 shows that cast steel structural

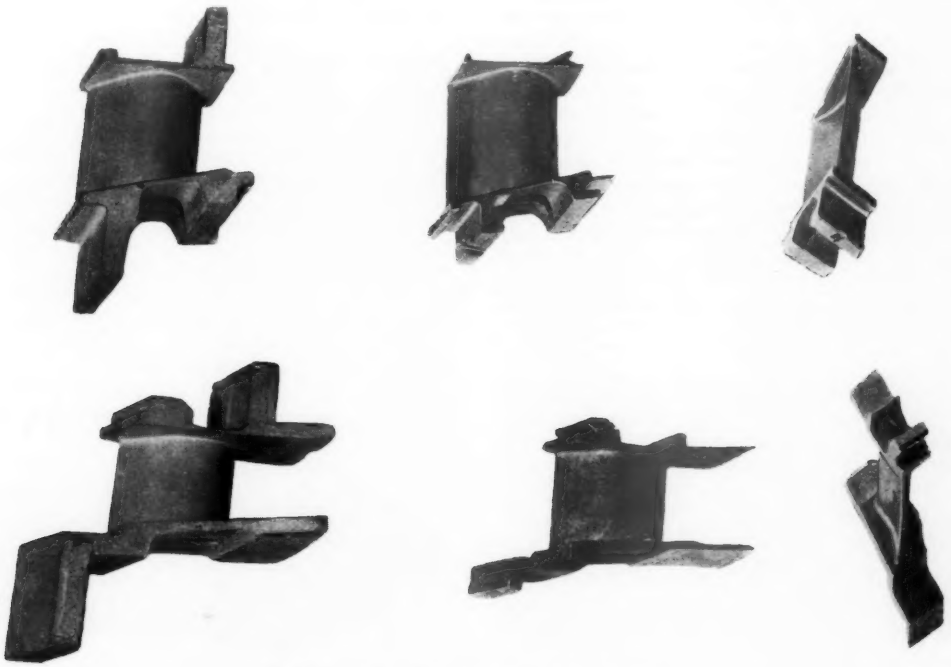


Fig. 22 Rolls-Royce Dart nozzle guide vanes

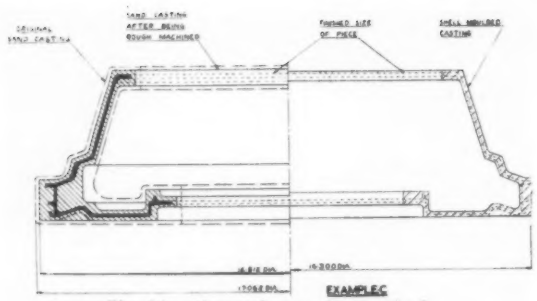


Fig. 23 Alternative casting methods

members are staging a come-back, in this case in a marine application. Where even quite small quantities are required, the cost of the pattern is very soon paid for by the saving in time in cutting out the steel plate and jigging and welding it up and inspecting the welds.

Where shapes are difficult to machine, as in the nozzle guide vanes shown in Fig. 22, the most expensive casting method, lost wax investment casting, can be justified. These components are cast to size on the aerofoil and the platform. The small size of the cored holes should be noticed and, in passing, it may be mentioned that these are not by any means the longest cores of their size which are being produced.

Bidding fair to produce castings of comparable accuracy is the shell process. As this requires a metal pattern, its use cannot always be justified, and there is a limitation imposed too by the complexity of the casting. Where profiles can be left as-cast which previously had to be milled, however, great savings both in metal and machining time are possible. Fig. 23 shows cross-sections of a casting produced originally in sand and weighing 107 lb. as cast, 11½ lb. finish machined. The first economy was to have the rough machining done by the foundry, since this put a higher value on the scrap than when it was returned from the customer. The final version, by shell moulding, weighs 38 lb., saves nearly £14 worth of material, and much machining.

A modern casting development which should help to reduce the cost of bar, forgings, and sheet is the continuous casting of billets. By avoiding piping and the other defects of ingots, an economy of about 30% is claimed, plus the elimination of ingot moulds.

Fabrication

Fabricated sheet metal parts occupy an important place in the aircraft gas turbine engine, for flame tubes, discharge nozzles, air casings, exhaust units, and jet pipes. The flame tube of the Derwent engine is shown in Fig. 24. Material utilisations as high as 56% are obtained with these components and they play a big part in the low specific weight of the gas turbine engine.

These components, and the flame tubes in particular, are interesting as representing an incursion into new fields of accuracy in sheet metal parts of their size. The flame tube is made from light gauge nimonic sheet, and since the efficiency of combustion and the life of the flame tube itself depend upon the accurate guiding and metering of a stream of air flowing through it at about 20 tons per hour, along carefully predetermined paths, it must be made extremely accurately. Since it is required in not very large quantities as compared with what is usual in the precision sheet metal field, and since the material is extremely difficult to form, requiring several anneals and draws in easy stages for many of the components, it has presented new problems of tooling and manufacture. Fig. 25 shows some of the stages of pressing some of the component parts of the Derwent flame tube.

The pressings must be free from internal stress, the welds must be of the first quality, and all free edges, as at joints and round the holes, must be carefully radiused and polished. The composite construction, too, entails great accuracy of trimming and locating to ensure that joints fit properly and that the overall tolerances on the assembly shall be met. Wherever possible, in order to improve material utilisation and to reduce the number of tools required, cylindrical components are made by wrapping sheet, welding and sizing.

The subdivision of the costs of material and the different manufacturing operations is rather revealing, as shown in Fig. 26.

The small part played by pressing and forming, and the relative importance of machining, locating, welding and finishing, are particularly noteworthy. This analysis is useful as indicating the directions in which efforts should be directed to reduce costs. One thing is immediately apparent–the cost of multiplicity of constituent components as affecting machining, locating and welding. This is in fact the biggest drawback of fabricated construction, and due account needs also to be taken of the cost of tooling, which will be roughly proportional to the number of constituent components.

As normally practised, the multiple sets of tools required for pressing nimonic components can become an expensive item. In this case expense means not only increased cost per component, but also greatly reduced flexibility and long delays in starting production or in introducing modifications. A considerable effort is being made therefore to reduce the number of tools required, by work along a number of lines. One process, known as Dyzacking, is able, by using a proportion of skill along with the necessary tools, to start production of components such as that in Fig. 27 for a small fraction of the tool cost, and several weeks ahead of the normal method. It is still uncertain to what extent this method will be

Fig. 24 Rolls-Royce Derwent flame tube

Fig. 25 Derwent flame tube—component stages

able to compete with the fully tooled method for really large quantities, but for orders of the appropriate size, and for a quick getaway, it represents a considerable step in the right direction.

Several other methods are being developed, aiming at similar flexibility of output, and more universal equipment, so that tooling costs will fall, and speed of introduction rise.

TYPICAL FLAME TUBE
Breakdown of Constituent Costs

		% of Total Cost
1.	Raw material	45.5
2.	Pressing, forming and shaping ...	6.7
3.	De-burring, radiusing and flash removal	14.2
4.	Preparation for welding, i.e. cleaning, jigging and tacking	9.0
5.	Welding and brazing	8.3
6.	Machining	12.0
7.	Miscellaneous handwork, etc. ..	4.3
	TOTAL COST :	100.0

Fig. 26 Breakdown of Flame Tube Manufacture.

Where a complex casting is replaced by a composite fabrication there will be in general an increase in cost, owing to the amount of tooling, accurate trimming, machining and handwork to control and correct welding distortion. In special cases, however, fabrication may be cheaper than a cast construction, and the following example well illustrates the danger of making too sweeping generalisations. Fig. 28 shows the original oil cooler of the Griffon power plant for the Shackleton aircraft. This had an outer and inner casing of cast magnesium. These had to be

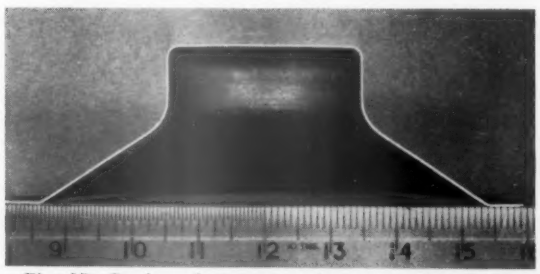


Fig. 27 Section of component formed by Dyzacking.
(Courtesy of Mark Tyzack, Ltd.)

Fig. 28 Oil cooler with cast casing for Rolls-Royce Griffon power plant

Fig. 29 Oil cooler with fabricated casings for Rolls-Royce Griffon power plant
(Courtesy of J. W. Lawrence, Ltd.)

Fig. 30 Marston Excelsior light alloy radiator for Rolls-Royce Merlin power plant
(Courtesy of Marston Excelsior, Ltd.)

machined to close limits, and difficulty was experienced in obtaining castings sound enough to withstand the test pressure of 100 lb. p.s.i. at 150°C, and in sealing the flow baffles against the inner casing. By reverting to orthodox sheet metal construction, using rolled and swaged brass sheet (Fig. 29), the weight has been reduced from 65 lb. to 46 lb. and the cost has been reduced by 9%.

Another rather striking example of sheet metal construction, in which the material utilisation is 90%, is the coolant radiator (Fig. 30) of the Merlin power plant used in North Star and Argonaut aircraft. This radiator, made entirely of light alloy, is dip-brazed by the Marston Excelsior process. It weighs 71½ lb. as compared with 118½ lb.—an excellent example of aptness for purpose, and it is up to 18% cheaper.

This is perhaps the place to mention the latest competitor of sheet metal — the plastic laminate. Reinforced with glass or other substance, plastics are providing a serious threat to steel for motor car bodies, and weight savings of up to 45% in body panels and hard tops are being obtained. With some of the latest reinforcing materials (not glass), costs 15% lower than those of orthodox steel parts are claimed.

This same Company again has achieved important weight and cost savings with its Marston Flexelite fuel tanks for aircraft. Made from nylon material of handkerchief thickness, impregnated with hycar, these tanks are crashproof, and after allowing for the additional structure to contain them, they weigh up to 33% less and cost up to 22% less than metal tanks.

Manufacturing Efficiency

It goes without saying that efficient shop management and planning play a big part in the ultimate cost of an article, but it is perhaps not generally realised how great in fact can be this influence, and how relatively easy it should be to effect really big improvements, to the benefit of all of us.

Fig. 31 shows, on a comparative basis, the costs of a number of components, produced by similar methods and at comparable rates, by different firms. This information has been obtained from a number of sources in a variety of industries, and amongst the components are machined parts, forgings, precision forgings and castings, pressings and fabrications.

Great care has been taken to ensure the accuracy and comparativeness of the figures. They take no account of capital expenditure on plant and equipment, nor of the cost of tooling for the particular components, so that they are in fact a good measure of the production efficiency of the firms concerned. Care has been taken to ensure that the figures are those which apply after initial teething troubles have been overcome, and that they hold for comparable quantities.

Through the co-operation of some of those concerned, it has been possible to discover a few of the factors responsible. In nearly every case there has been an acceptance of the existing state of affairs as unavoidable, while just plain bad costing has been the next common factor. A great value of the investigations has been the discovery of differing

detail practices which have had a considerable influence upon overall material costs and labour times.

Amongst these differences were found in one case a material utilisation of 41%, as compared with 55% in the best case, and accounting for £4 in the cost of a £20 component; in another, a rejection rate double that of the best case, due to the unexpected effect of an "economy" measure; in another, an excessive amount of corrective work which was eliminated by a simple change of method; in yet another, excessive scrap due to inefficient inspection. Differences in incentive methods, and in such elementals as effective shop loading, have had a big influence upon manufacturing times, so much so that differences of 100% have been seen as applying to identical components made by identical methods. It is perhaps not without significance that the best results have in some cases been obtained where there has been least expenditure on tooling.

One overriding difference which is apparent between the better and the more costly concerns is in the outlook of the personnel involved. Those producing the best results have in common a simple, direct and confident approach to the job. This has led to a questioning of the methods and results achieved at each stage, and a refusal to accept the obvious until it has been checked and confirmed. By this means it has been found relatively easy to avoid or eliminate inefficiencies which have had a big bearing on the cost of the component.

Reclamation of Scrap

With three-quarters or more of the original ingot metal being discarded as croppings or mill loss or machinings or spoilt work, there is a fruitful field for recovery. This scrap metal, plus that which is collected as salvage, now bulks largely in our overall metals economy. For instance, up to 30% of our tin, 35% of our copper, and 40% of our lead comes from scrap.[10] An appreciable portion of this reconverted scrap comes from salvage, which is becoming increasingly important. Many thousands of tons of aluminium in the form of milk bottle tops, chocolate wrappings, and so on, become waste every year. Collections are made from municipal authorities, and up to 4 tons of ferrous scrap per 1,000 of population is gathered in. In addition, about half a million tons of ferrous scrap are imported every year.[11]

In the case of alloys, their cost ensures a more careful and rapid return of waste. That occurring in the cogging or rolling mill and the foundry, for example, finds its way back to the furnace pretty quickly. Careful segregation eases the problem of remelting into the desired alloys but nevertheless a good deal of work has had to be carried out, and much care is necessary, to ensure consistency and accuracy of the alloys produced. This is even more difficult with machinings, where cutting oils, dirt, and foreign matter may have been introduced.

It is especially noteworthy, then, to see that it has been established recently that machining scrap of high alloy heat resisting steels can be reclaimed most economically and even the highly critical nimonic

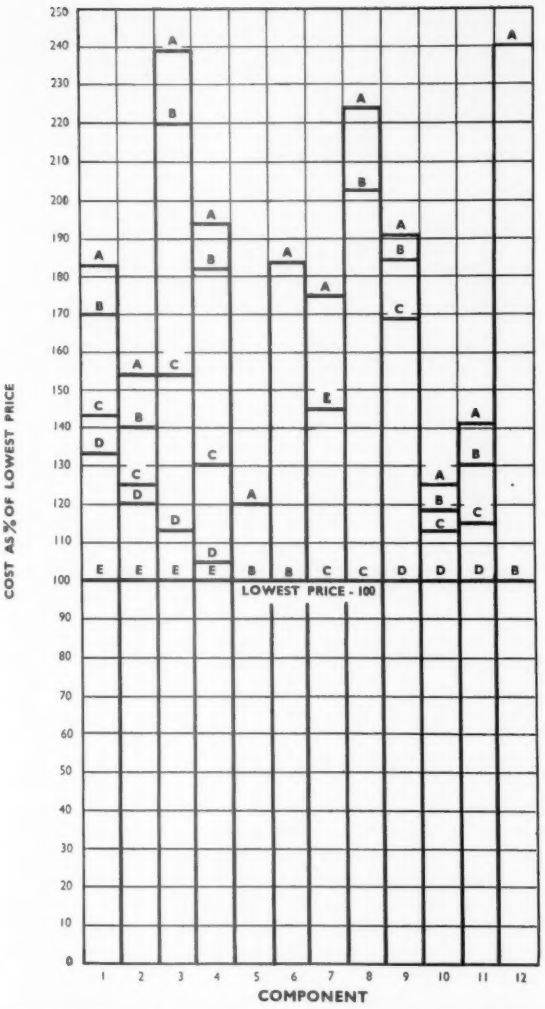


Fig. 31 Comparison of manufacturing costs

alloys can now be reproduced safely from their machining scrap. This is indeed an achievement, since the slightest trace of adulterant such as lead can completely ruin a melt. Even if this reclamation were uneconomical financially, it could in time of emergency become absolutely vital.

Mention has been made of the difficulties with titanium. The lack of a recovery method is one of the big factors in the high cost of this metal, and it goes without saying that a good deal of effort is being concentrated upon this problem.

Most people will remember the collection of aluminium pots and pans which went on during the Battle of Britain. Although the sacrifices of the housewife did not find their way directly into highly-stressed components, the increased availability of scrap metal undoubtedly helped the overall situation. And now it is interesting to see that she is getting her

Fig. 32 Scrap airscrews for remelting
(Courtesy of John Dale, Ltd.)

own back. Fig. 32 shows heaps of scrap light alloy propellers which are converted, along with the aluminium components of the rest of the aircraft, into the pots and pans of Fig. 33.

Scrap recovery of this kind has been going on for a long time. One of the big advantages of the discovery of the casting process, in the Bronze Age, was that tools and weapons which had broken or worn could be recast as good as new, whereas the earlier hand-forgings could not be reclaimed. Fig. 34 shows a founder's hoard of scrap which is about 3,500 years old.[12] A more recent example, Fig. 35, shows a foundry in the year 1590 A.D., where cannon are being produced mainly from headers and burst cannon. It will be seen that the metallurgist is busy trying to evolve a better alloy to overcome these failures, while a cheap source of power is being used for the blowing engine.

Scrap material due to spoilt work can, of course, be recovered along with manufacturing waste. It is, however, more important to the production engineer because it includes an additional labour content. The way in which this problem is attacked depends, as do so many other things which have been under review, upon a complex set of circumstances, and it is conceivable that where the reduction of spoilt work requires expensive new methods, it might be cheaper to live with the existing scrap. In all cases, however, it is important that the labour content should be kept as low as possible. This means that spoilt material should be detected as early as possible in the manufacturing cycle, and here inspection can play a big part, by eliminating unsound bar before it is cut into slugs for forging, or unsound castings before they are passed to the machine shop, or unsound sheet before it is blanked for pressings. The part played by inspection in keeping down the proportion of work spoilt in subsequent manufacture needs no comment.

Repair and Maintenance

The last War probably brought home to most of us how big a part can be played by repair in increasing the utilisation of materials by extending life. "Make

Fig. 33 "Daleware" produced from scrap airscrews
(Courtesy of John Dale, Ltd.)

do and mend" became a catchword, and the ingenuity of salvage methods, and their effectiveness, surprised us all. Yet even now we have not fully realised the value of preventive maintenance and overhaul and applied them on a sufficiently wide scale.

Because of their inherently high duty, aircraft engines are usually given short overhaul lives when they are first introduced into service. At the expiry of the specified time, which during the War was 300 to 400 hours for piston engines, the engines are withdrawn for a complete overhaul, which restores them to their full original effectiveness and reliability, for a fraction of their prime cost. It is the constant aim to increase the overhaul life and to reduce the cost of parts needing replacement, and it has already been stated that the civil Merlin 724 engine is operating at an overhaul life of 1,250 hours. In the case of the

Fig. 34 Bronze founder's hoard of scrap metal, *circa* 1600 B.C.

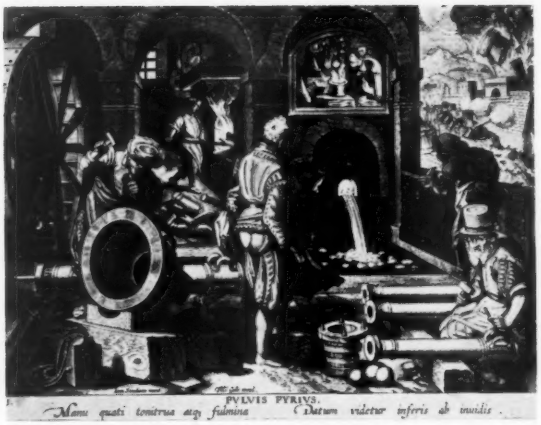


Fig. 35 Cannon Foundry, *circa* 1590 A.D.

Avon Mark I engine the results have been most gratifying for such an early stage of development, and Fig. 36 shows the small number of parts needing replacement after 800 hours of service. During the War, despite the heavy losses in combat, the overall value of the original effort put into building Merlin engines, as measured by the total engine flying hours, was doubled by repair. An extremely important aspect of repair, especially when it is effected by replacement of worn parts, which are returned to main base for salvage, is that large sources of lower grade labour can be tapped in times of emergency.

In civil aviation, planned maintenance is carried out on scientific lines. Although the aircraft engine may seem to have a relatively short life between overhauls, the time it is out of commission, and the cost of overhaul, are small. Taking everything into account, the cost per horsepower hour of the aircraft engine compares favourably with that of any other engine in its power class. Rolls-Royce are now overhauling their civil engines on a guaranteed cost per flying hour basis, which means that the operator knows just how much his power is costing him for as long as he likes to keep the engines in service. This provides an incentive to build good, and it is suggested that a similar scheme of planned maintenance could with advantage be applied to other products such as machine tools.

Planned maintenance is usually based upon repair by replacement. The worn or defective parts can often be made good for another tour of duty by reclamation. Low duty worn parts of stationary engines may be built up by metal spraying. Cracked or collapsed flame tubes may be repaired by welding in complete new sections, as can motor car doors which have rusted through. Wherever possible, the detail design should permit the easy replacement of components which have a shorter than average life, thus enabling full value to be obtained from the remainder.

Other factors may enter the picture. Thus the period between flushing out of radiators in Argonaut power plants has been extended to 2,500 hours, largely due to the use of a sprinkling of sodium mercapto-benzothiazole in the ethylene glycol coolant, to prevent corrosion and silting. In this same field of heat exchangers startling progress was made during the War, notably by J. W. Lawrence Ltd., of Leicester, who developed a method of completely breaking down soft-soldered copper secondary surface radiators and rebuilding them as good if not better than new.

Similarly, automobile radiators, huge numbers of which are scrapped annually, particularly in the United States, can be fully restored for about 30% of the original cost.

Sales and Service

By no means least in the integrated influences upon effective utilisation are the parts played by the Sales and Service Departments. It is probably because we are all subjected to so much salesmanship that we are inclined to overlook these. Yet in the final analysis both play as vital a part as any in ensuring that the work of designers, production engineers, and all the rest can be put to effective use.

The Sales Department bears the responsibility for studying markets and the needs of the customer and providing management and design with information to enable the right policy to be laid down. In all cases this involves forecasting the future, but where the product requires a long period for its design, development, tooling and manufacture, the difficulty of ensuring that a company shall be producing the right product at the right time is correspondingly greater. In the case of the aircraft engine, to be guessing correctly five or seven years ahead, when such large sums are involved in development, puts a great burden upon the sales engineer, management, and designer alike.

It is equally important to ensure that the customer chooses the most suitable product for his purpose, and

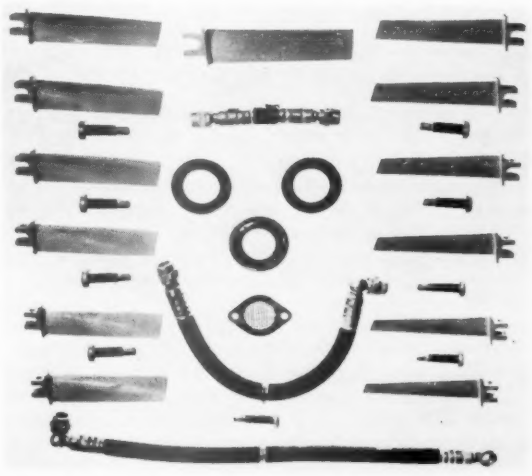


Fig. 36 Parts requiring replacement after 800 hours' service—Rolls-Royce Avon Mk. I engine

in the cases of prime movers and machinery this may require a good deal of technical study.

The Service Department is responsible for ensuring that the product is correctly used and maintained. The importance of this work is being appreciated more and more, as we see by the current rapid increases in size of service departments in many companies. This enlightened long term policy has a direct influence upon effective material utilisation by ensuring that maximum life is obtained by the avoidance of abuse.

CONCLUSION

The inference to be drawn from the foregoing is that there is no simple general rule for good product engineering and effective utilisation of material. Success can only be achieved by making a thorough study of all the factors involved in each case, and in particular by marshalling to best advantage all the talents, skills and techniques which are available in the individual organisation.

Although it has been shown that such studies can lead to widely differing conclusions in different cases, they have one thing in common. This is the great part played by commonsense and by the straightforward down-to-earth approach. Striking improvements may be made by relatively simple changes, and it is important to realise that many of our problems are not new, but are of types which have faced production engineers since the days of pre-history. Indeed, many of our current difficulties are of our own making, since the general susceptibility to jargon, catch-phrases, and "headline thinking" is leading to stultification of honest thought, so that fundamental issues become hidden under a burden of meaningless verbiage and alibis. With our limited resources, the tendency to assume that a process or a machine must be good if it is new needs to be resisted, and in the majority of cases it is contended that existing methods can be made at little cost to better the performance of the new.

Similarly it is necessary to see through the haze of glamour which now surrounds the science of production to the basic underlying truths. For example, in the excellent review by Mr. Graham Hutton of the sixty-six reports of the teams which compared American and British industrial efficiency,[13] the value of a little extra work per man gets only one reference in a footnote. But when Lord Hives was asked what was the secret of success of Rolls-Royce, he replied, "There is no secret: it's just plain hard work".[14] And those who have seen the way in which firms in Germany and elsewhere on the Continent are gaining ground have no doubts on this score.

This can be amplified by the following quotation from the life of Richard Trevithick, by Dickinson and Titley[15]: "He had the true mechanical instinct which goes to the core of a problem and sees the best way to attack it; he bubbled over with ideas, he was a bold and original experimenter, while nothing could withstand his tremendous energy. In spite of the limited theoretical knowledge of his day, he grasped fundamental principles and hence visualised the right line of advance. While other men would be revolving an idea in their minds, he, with apparent recklessness, would be making an experiment under the severest possible conditions, those of every-day work."

While it is not given to all of us to possess all of these attributes, they are essentially British. By directing our thinking more along these simple straightforward lines, we shall be able to bring about a much earlier realisation of improvements in that field which is described by that blessed but much abused and often misunderstood word which so far the author has refrained from using, Productivity.

ACKNOWLEDGEMENTS

Grateful thanks are due to those firms who have assisted the author by providing information and photographs. He would like to take this opportunity of thanking too those who have helped with the preparation of the Paper and the slides, and in particular Mr. W. G. Cook, who has helped in the collection of technical information.

Lastly, the author thanks the Directors of Rolls-Royce Ltd., for permission to publish the Paper, and points out that the opinions expressed therein are entirely his own.

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COMMUNICATIONS

The following communications on Papers in this issue have been received.

"THE EFFECTIVE UTILISATION OF MATERIAL"

From:* Sir Walter Puckey, *President of the Institution

Under a title which, while very important, does not excite our imagination, Mr. Nixon has written a very fine Paper. He has never lost sight of his title, but has approached it on such a broad front that his Paper contains much fascinating and valuable information, of use to every production engineer.

Mr. Nixon's company has a great place in the field of high performance products and those, like myself, who have been fortunate to observe how it holds that place, realise that this leadership is maintained by those British characteristics which for long held the envy of the world—high engineering competence, directed and applied with imagination, courage and energy.

It is in this field of high performance engineering equipment that Britain made her name, and on which she is likely to rely in future. Mr. Nixon, rightly, points out that there are few "mass production" units in Britain (although we do know of a few good ones), and our particular flair has become evident in designing, developing and producing a greater variety of products. This calls, and will continue to call, for better developed qualities of extemporisation, of flexibility of outlook, and more than ever before, for an ability to produce this greater variety of products with relatively less expenditure on imported materials and new plant.

Mr. Nixon's approach to the better utilisation of materials reminds me of the approach to manufacturing costs. There are some who concentrate on direct labour cost and tend to ignore overheads. Others say that it is total cost that matters and that the ratio of direct to overheads is not significant. Like all arguments each has something on its side, but on balance it is *total* cost that matters first, as it is total effectiveness of a product rather than the ratio of material cost to labour cost.

Production engineers have had a great challenge in recent years. The spate of new materials has called for great ingenuity in fabricating and utilising them, and Mr. Nixon gives us some impressive examples. He shows, too, how much more important it is for the production engineer to consider carefully today the choice of manufacturing techniques open to him, because wrong choice may easily cripple the opportunity for design changes, which inevitably are more frequent and necessary to maintain Britain's place in the sun.

So much could be written about this Paper; but the best advice is to read it carefully and apply its reasoning. I congratulate Mr. Nixon and the Derby Section on a valuable Paper.

From:* Mr. R. M. Evans, *Chairman of the Institution's Materials Handling Sub-Committee

The subject of this Paper is, I feel, a matter of the very greatest importance both to production engineers and to the nation as a whole, and is one that deserves far more attention than is usually accorded to it.

In stressing the importance of basic design and fitness for purpose, Mr. Nixon goes to the root of the matter and in postulating the overall efficiency of the product he draws attention to the need to look at this question of material utilisation on the broadest basis.

Mr. Nixon's example of the aero-engine is, of course, in many ways, an ideal subject, insofar as there is a ready measure of efficiency by comparing the output of power against the weight and cost of the engine; furthermore, the savings to be achieved when using such expensive materials as are employed in these products are very apparent. Nevertheless, although it may be less easy to make such direct comparisons in other products, the study of what proportion of material is turned into something efficiently useful should be amongst the first considerations of the designer and to this end it is essential that there should be the closest co-ordination between the designer and the production engineer from the earliest stages. There is still far too much tendency on the part of designers to shut themselves into watertight compartments and for them to resent any suggestions from the production engineers; the attitude of: "It's my job to design the thing, it's your job to produce my design", is not the way to an efficient product at the lowest cost.

As a nation we simply cannot afford to ignore the appalling losses that occur between the raw material and its final use; we are dependent upon the importation of most of our materials from outside these islands and the greater proportion of these materials we can turn into saleable products, the greater our prosperity. We must not be content with the attitude that the only way to make certain things is by the methods that have been in use for generations; we should constantly question accepted ideas and continually search for better methods and improved designs.

Material Utilisation is a big subject and no one production engineer can tackle the whole subject in its entirety. It therefore behoves every one of us to keep it constantly in mind. As Mr. Nixon shows, it cannot be separated from other aspects of research and design.

As Chairman of the Sub-Committee on Materials Utilisation, I would commend Mr. Nixon's Paper to every manufacturer, large or small.

"PRODUCTIVITY — ARE WE ON THE RIGHT ROAD?"

From:* Mr. P. Grodzinski, *(Diamond Research Department, Industrial Distributors (Sales) Ltd.)

I was very impressed by Lord Sempill's lecture, as he viewed quite a number of points which a student and lover of this country has evidenced many times. His full quotations from American development and European recovery may have had some adherents who considered them as examples to follow. His real point, as I understand it, was, however, to draw our attention to these facts, in the sense of not to copy but to understand and to study. Of course, this can go to the extreme in one's own mind and lead to Madame Staël's saying: "Tout comprendre c'est tout pardonner". I personally believe that in this country the study of foreign countries, their developments and achievements, is usually inadequate. I should like only to cite an abstract bulletin well-known to all production engineers, which does not include any abstracts from journals, other than in the English language. This approach was the main incentive of the writer when he contacted English publishers as early as 1933 and he has to state that this was reciprocated in most cases and developed to lasting friendships. Therefore I should like to add to Lord Sempill's suggestion that examples from foreign countries can be most appropriately given by the expediencies of the technical press.

A personal reminiscence was struck when Lord Sempill dealt with the problem of rail transport and vividly described the advantages of fitting continuous brakes to goods trains. It is exactly thirty years ago that the writer undertook a period of training at the German State Railways after having graduated. At this time Germany was in the throes of the inflation and except probably the post-war period, there was no time more difficult for the people, but at this time all goods trains were equipped with through-going brakes which are still lacking in this country.

In the Paper and in the discussion it was clearly brought out that one of the difficulties is that industry is guided by the principles of accountancy as developed for banks, insurances and government departments. Should not the production engineering approach be extended to this field? I believe that the German institution of Wirtschaftspruefer, i.e. engineers with understanding of economy, is also more than twenty-five years old and as a generally recognised institution has not yet found a similar expression in this country.

COURSES IN WORK STUDY

Last year the Anne Shaw Organisation organised a programme of short courses on different aspects of Work Study, designed especially for those not primarily specialists in this field, but whose normal occupation impinges on it and calls for practical knowledge of the subject.

These courses were so successful that they are being repeated, and full particulars may be obtained from The Anne Shaw Organisation, Beech House, Heald Green, Cheadle, Cheshire.

C.G.L.I. INSIGNIA AWARD IN TECHNOLOGY

The Insignia Award in Technology was established by the Council of the City and Guilds of London Institute some twelve months ago, to provide a high qualification for persons in industry whose initial training was based primarily upon practical experience combined with theoretical study and who, having gained appropriate City and Guilds' certificates as craftsmen or technicians, have now advanced in their industry by a combination of progressive experience and further study.

A candidate upon whom this Award is conferred will receive a Warrant specifying the section of industry and the branch of technology in which his knowledge and skill are recognised, and will be authorised to use the insignia letters, "C.G.I.A."

A copy of the Regulations governing the Award, together with notes for the guidance of candidates, may be obtained on application to the Director, Department of Technology (I.A.), City and Guilds of London Institute, 31 Brechin Place, London, S.W.7.

THE VISCOUNT NUFFIELD PAPER — REPORT AND DISCUSSION

(Concluded from page 158)

of coal per man per day extra in the coal industry would put the country on its feet as far as the coal industry was concerned and would provide a useful amount—millions of tons—for export. One extra shovelful a day from the man at the face! Someone had to tell that chap in words that he understood—simple words—just what it meant to himself and to his family and to all the rest of the people. That was what Lord Sempill had done—he had given a simple Paper in simple words on what could be achieved.

It was the attitude of mind of the people who ran the works that needed to be got at. Let them take Lord Sempill's words to the men who ran the factories, because it was quite true that the output of this country could be pushed up at least 25 or 30 per cent.

They knew Lord Sempill as an intelligent, kindly, lovable man and those who were his friends knew him for a loyal friend. Therefore they were all glad to honour him by coming to hear him and be glad he had been honoured by being invited to read the Paper. General Appleyard had great pleasure in proposing that a hearty vote of thanks be accorded to him.

The vote of thanks was carried by acclamation. The proceedings then terminated.

MEASUREMENT IN GEAR MANUFACTURE

by R. D. B. STONE

Manager, British Gear Grinding & Manufacturing Co. Ltd.

An abridged version of the Paper presented to the London Section of the Institution on 5th March, 1953.

BEFORE the introduction of gear cutting machines, improvements in gear tooth accuracy resulted from careful observation of the gears in service. The natural tendency for a pair of gears to function more freely after a period of running, and the shape to which the teeth wore themselves were carefully noted to serve as a future guide and much depended upon the marking and freedom of roll between a pair of gears.

Today gear producing machines are built to the highest standard of accuracy, and there is a wide range of sensitive and searching inspection equipment, but it is still true to say that in many applications of gearing, the rolling and marking test is still the key one.

Where key teeth are checked by direct measurement, the elements commonly to be measured are :

Tooth Thickness. This is controlled so that a pair of gears may rotate freely at their designed centres without coming into hard mesh under normal running conditions. Provided that there is sufficient backlash to ensure this, a slight further reduction in tooth thickness is in many cases of no great significance. Timing gears and any application of gearing which controls phasing are exceptions. In such cases very close tooth thickness tolerances are set, and many devices have been introduced such as split gears in order to eliminate or obtain minimum backlash.

Involute Form. Upon the accuracy of this depends the maintenance of constant angular velocity. Variations from a true involute cause accelerations and retardations, resulting frequently in noisy gears and surface failure such as scuffing or scoring. Slight easing of the tips of teeth is permitted in order to alleviate harsh engagements and so reduce this type of surface failure.

Eccentricity between a pair of gears will cause a variation in backlash during rotation and, if excessive, may bring the teeth into hard mesh. Eccentricity in heat treated gears arises not only on account of heat treatment distortion, but frequently during the bore grinding operation, through failure to set up accurately to the teeth. Unless a subsequent tooth finishing operation such as gear grinding is called for, there is little remedy.

Spacing Errors are often allied to eccentricity errors and can give rise to similar troubles. Eccentricity and accumulated pitch errors, if present in a moderate degree, can be harmless, but if the pitch errors are concentrated over a few teeth, then noise and other faults are likely to arise.

Misalignment of teeth or lead errors in the case of helical gears will cause load concentrations, which may cause surface failure such as pitting or even tooth breakage.

Poor Surface Finish may also cause load concentration, and is certain to be accompanied by noise and loss of efficiency.

Gear Hardness

In the case of hardened and ground gears, particularly highly stressed aero-engine gears, the most rigorous and searching tests are applied. Hardness testing by diamond indentation and magnetic crack detection are often not in themselves enough. Chemical or electrolytic etching of the tooth surfaces may also be carried out to reveal cracks and the presence of any local rehardening or tempering that may have occurred during tooth grinding.

Measurement of Tooth Thickness

One of the commonest methods of expressing gear tooth thickness dimensions is to give the chordal thickness at the pitch line, and the corresponding chordal height or chordal addendum. These dimensions can be checked directly by means of the widely-used tooth vernier caliper gauge, but the jaws of the gauge, being knife-edged, are subject to rapid wear. There is also the danger of a difference of "feel" between one gear inspector and another and, furthermore, the gauge locates from the outside diameter of the gear, which may not be held to a particularly close tolerance. For reasonably accurate readings, it

might be necessary to control the outside diameter to within unnecessarily close limits or waste time inspecting for variation in blank diameter.

The Constant Chord Method

Whereas the Chordal thickness at the pitch line varies as the number of teeth in a gear, the Constant Chord is not affected by change of tooth number, remains constant between gears of like pitch having an equal amount of correction, and is independent of the spiral angle.

The Constant Chord is the chordal distance between the points of contact of a tooth with its mating teeth, when that tooth lies symmetrically in the tooth space of its mate with respect to the line joining the centres of the two gears. That is to say, that under those conditions of symmetry, the common tangents to the base circles of the two gears will, at the points at which they intersect the opposite faces of the tooth nearer the crest, subtend the Constant Chord.

The Constant Chord height is the distance of this chord from the tooth crest. Although the Constant Chord method of expressing tooth thickness is a uniform one and for gears of the same pitch influenced only by the correction factor, the shortcomings of the tooth vernier caliper still apply.

The Base Tangent Method

A popular way of measuring tooth thickness without reference to the outside diameter is by the Base Tangent method, by which the dimension checked is the length of the base tangent contained by the opposite faces of two or more teeth.

The number of teeth over which the measurement is taken determines whether the measuring anvils contact towards the tips or the roots of the teeth. On a given gear the higher the number of teeth over which the measurement is made, the nearer the contact is to the tips of the teeth and *vice versa*. The calculated dimension over the selected number of teeth can be checked with a normal vernier caliper or a micrometer, special micrometers with large diameter thin section anvils being made for this purpose. The resultant accuracy will be that normally associated with the use of micrometers.

This same method of measurement can be applied to helical as well as spur gears, although in the case of helical gears the calculation for the base tangent length is more involved.

A possible limitation to this method of measurement, peculiar to helical gears only, occurs when the gear face width is very narrow. It is usual to make an initial check to ensure that the length to be spanned is in fact contained within the face width, the reason being that the measurement is made normal to the gear helix.

A further method of tooth thickness measurement involves checking the dimensions over rollers inserted in the teeth at 180°, or approximately 180° in the case of gears with an uneven number of teeth. It is common practice to use rollers or pins of such a diameter that they contact the tooth flanks on or near the pitch line. This method is a very sensitive one as, owing to the wedging action of the rollers in the tooth spaces (with gears of the normally encountered pressure angles), it will be evident that an alteration in tooth thickness will cause displacement of the rollers by an amount greater than the tooth thickness variation. Involving as it does, the use of a micrometer and two rollers which have to be kept in position whilst the reading over them is being taken, this method despite its greater accuracy is less speedy than the base tangent method.

Tooth thickness can also be measured by meshing the gear to be checked with a master gear and noting the centre distance at which the pair are in close mesh.

Involute Form

In order to determine or measure the accuracy of the involute form, it is necessary to employ special machines of high sensitivity and considerable cost, if results to the order of a few ten thousandths parts of an inch are required.

It is possible to measure the tooth thickness at various heights on a given tooth and note the deviations from the calculated thicknesses at those heights; but this method suffers from the disadvantages associated with the use of the tooth vernier caliper gauge. Furthermore, it has to be assumed that the tooth is symmetrical and that any error discovered is divided equally between opposite flanks.

Referring to machines specially designed to measure the accuracy of involute form, the principle commonly employed is the basic one of involute generation, namely, the rolling of a straight edge without slip round a base cylinder or diameter equal to the base circle diameter of the gear to be checked. The straight edge normally carries a pivoted stylus, one end of which makes contact with the gear tooth, the other with a dial indicator. Many machines also incorporate an automatic graphical recorder.

This type of machine requires a base cylinder for every gear of different base circle diameter. Great precision is required in the manufacture of the base cylinders, and therefore if a wide range of gears is being dealt with, a considerable number of costly tools is required.

Some involute measuring machines employ a single master base cylinder or master involute cam and, within the range of the machine, can by means of ratio arms, a sine, or similar mechanism be set to any required base circle diameter.

Tip Relief

Tip relief is permitted as an aid to gear manufacturers, and helps to avoid harsh engagement which might otherwise arise owing to the presence of tooth spacing or similar errors. In the case of highly stressed gears, where appreciable tooth deflection occurs under load, tip relief is necessary in order to compensate for this deflection.

In order to appreciate how this relief is applied and measured, it is necessary to consider the cycle of engagement of a pair of teeth.

When a pair of teeth first make contact at the lowest active point of the driver and the tip of the driven teeth, the load is already being shared by another or other pairs of teeth already in mesh. Assuming the contact ratio to be less than 2, as engagement progresses a point is reached at which the whole load is being taken by a single pair of teeth and this condition remains until in their turn the following pair of teeth make contact and take their share of the load.

The result is a zone of single pair contact, limited according to the contact ratio of the gears in question, during which the full load is carried by a single pair of teeth.

With highly stressed gears, it is normal for a true involute to be aimed at during single pair contact. The critical points are the limits of the single pair contact zone, i.e. the point at which the load is first fully taken by a single pair of teeth, and then the point at which the load is first shared by the following pair of teeth. Therefore, tip and/or root relief as applied to highly stressed gears is measured from the limits of the single pair contact zone.

The way in which the relief is applied may vary considerably. One gear of a pair may be true involute over the whole of its active profile, whilst the other may carry all the necessary tip and root relief. Alternatively, both gears may have tip relief only, or the same gears may both have a reduced amount of tip and root relief.

However applied, the relief should be measured with reference to the limits of the single pair contact zone. It is also highly desirable, when measuring gears with such reliefs, to employ a machine which gives a graphical record, so that the points from which the relief is measured may readily be picked out.

Involute form measurement by optical projection can also be carried out, particularly with the finer pitch gears, but a large scale drawing will be required for each different gear checked by this method. Furthermore, with a magnification of x 50, the outline of the enlargement must have an accuracy of less than .01″ if errors on the gear of less than .0002″ are to be discovered.

Projection can be used to check most tooth elements, although where high power magnification is involved, only the smaller and finer pitch gears will come within the field of the normal projector.

Master gears can also indicate the presence of involute errors, although not normally their magnitude. It is a not uncommon practice to manufacture master gears with controlled negative relief or root interference, so that when rolled with a component a definite indication is given when tip relief is present.

Tooth Spacing

Tooth spacing is in its measurement closely linked with involute error. Probably the commonest and simplest method of measuring tooth to tooth pitch errors is by means of a hand or bench instrument. with a fixed anvil locating on the flank of one tooth and a pivoted stylus operating a dial indicator locating on the flank of the adjacent tooth. The pitch is arbitrarily set and a comparison taken of the readings between each pair of adjacent teeth round the gear.

Although this method indicates the presence of spacing errors, it does not indicate directly which teeth are spaced correctly according to the true pitch of the gear, and variations in the involute form round the gear will affect the readings obtained. Again, this system does not indicate the accumulative error, but by recording a set of readings so obtained, it is possible for it to be calculated. Bearing in mind that the pitch was arbitrarily chosen, it follows that if the algebraic sum of a full set of readings round a gear is taken, and then divided by the number of teeth in the gear, the result will be the difference between the true pitch and that chosen at random. By correcting the set of readings by this difference, further readings are obtained relative to the true pitch of the gear. These can then be plotted graphically, and the difference between the crest and trough of the graph will give the accumulative error.

An alternative method of checking pitch errors is by means of an optical dividing head or an accurate index plate, with its number of slots corresponding to the number of teeth in the gear to be checked. With this type of apparatus, the gear can be indexed by an amount exactly equal to its true pitch.

Errors of concentricity or the eccentricity of gears may also be associated with spacing errors. The commonest means of measuring eccentricity is by a rolling check with a master gear. Quite frequently a master gear is hand rolled with the gear to be checked, and the degree of smoothness of roll will give the experienced inspector a good indication of the involute form. Serious tooth spacing errors can also be discovered by this means.

It is more usual, and this applies to eccentricity checks, to mount the master gear and the component on separate spigots or between centres on an instrument designed so that, whilst one spigot is fixed relative to the instrument, the other is free to slide in order to allow a variation in centre distance between the master gear and the component, according to inaccuracies that might be present. Close mesh is maintained by spring loading, and variations in centre distance are recorded by dial indicator gauge or a graphical recording device. Instruments for rolling tests are normally fitted with a vernier scale attachment, so that the fixed and sliding spigot can be set at the requisite centre distance.

As an alternative method of checking eccentricity, the gear may be mounted between centres and a series of readings taken over a roller placed successively in tooth spaces at reasonable intervals round the gear.

Tooth alignment of spur gears can be measured quite simply by running a dial indicator gauge along a tooth in a path parallel to the gear axis. Again, spur and helical gears may be run with master gears and the presence of tooth alignment or helix angle errors noted from the marking obtained.

The use of master gears will not indicate the amount of any errors, and it is therefore necessary, in the case of helical gears, to use a lead measuring machine in order to determine their extent. Most lead measuring machines consist basically of a tracing point or stylus which moves in a path parallel to the axis of the gear under test, coupled to a suitable mechanism for imparting the appropriate angular motion to the gear in constant and direct relationship to the axial travel of the tracing point. In effect, the tracing point describes a true helix with respect to the arbor on which the gear is mounted and any deviations between the true helix and the actual helix of the gear under test can be read from a dial indicator gauge.

Surface Finish

Except in the case of profile ground aero-engine gears, it is extremely rare to find the degree of surface roughness specified on a drawing. Even amongst aero-engine manufacturers there are some who specify surface finish to a very close tolerance in terms of micro-inches, and others who make no reference to it at all. It is safe to say that the vast majority of gears produced are subject to visual inspection only for surface finish. There are, of course, well known machines for checking surface finish, by means of a tracing point of extremely small tip radius coupled to an electrical recorder for amplifying and recording the degree of roughness, but such instruments are rarely employed. Where finish cut gears are involved, visual examination is normally sufficient.

Other tests commonly carried out include hardness testing, which is naturally applicable to components other than gears and testing for noise. Silence of operation is essential, since this is a good criterion of general accuracy. However, in some cases gears are slow running and inaccuracies which might give rise to unpleasant noise at high speed may be acceptable at their actual speed. Also, noise set up by other components or mechanism may be of such an order that extra expense involved in producing perfectly silent gears would not be justified.

Noise testing is normally carried out on a machine which simulates as closely as possible actual gear running conditions, the resultant noise often being amplified by some simple megaphonic device.

It is well-known that grinding can be abusive to the material and because of this inherent danger it is sometimes necessary to apply an inspection procedure more searching than the hardness test. Where considered necessary the gears may be dipped in a bath and chemically or electrolytically etched, when the whole of the tooth surfaces are attacked in varying degree according to their hardness. When examined after removal from the bath, the gears should be of a uniform shade, and the presence of light and dark zones indicates a variation in hardness.

When confronted with a gear drawing and the finished product, a gear inspector may in many cases find that very little information is given with regard to the final accuracy of the tooth elements already outlined. Certainly, B.S.S.436 sets out the permissible tolerances for different classes of gears, but the art of inspection lies in an appreciation of the function of the gears, together with a sound knowledge of the effect of various errors which may be present. A gear inspector must also have a clear understanding of the way in which errors of certain tooth elements are closely linked if he is to be able to differentiate between them. He is then in a position to select the speediest and most suitable method of measurement in accordance with the accuracy required and the equipment available. No matter how wide the range or how sensitive the measuring machines at the disposal of an inspector, the results will always depend upon the intelligence, experience and adaptability of the person who uses them.

(The full text of this Paper is available to members on loan from the Hazleton Memorial Library.)

FUTURE INSTITUTION ACTIVITIES

In addition to the meetings listed in the Journal Supplement, the attention of members is drawn to the following important events :-

Production Exhibition and Conference, Olympia, London, July 7th/14th, 1954.

" Trends in Production Engineering "— Conference organised by the Norwich Sub-Section, to be held in Norwich, 2nd/3rd April, 1954.

" Information and the Production Engineer "—Joint Conference with Aslib Aeronautical and Engineering Groups, College of Aeronautics, Cranfield, 2nd/5th April, 1954.

Full particulars of these Conferences may be obtained on application to the Secretary, 36, Portman Square, London, W.1.

REPORT OF THE ANNUAL GENERAL MEETING

Thursday, 28th January, 1954

THE 32nd Annual General Meeting of the Institution was held on Thursday, 28th January, 1954, at 11 a.m., at the Headquarters of the Institution, 36, Portman Square, London, W.1. The President, Mr. Walter Puckey, Kt., was in the Chair.

The President explained that the Chairman of Council, Mr. Harold Burke, had been unavoidably delayed on his journey from Birmingham, but he hoped to join the meeting later in the day.

New Articles of Association

Mr. G. R. Pryor, in moving the adoption of the new Articles of Association as set out on pages 56/62 of the January, 1954, Journal, said that the motion was the culmination of a very long, arduous and sometimes fatiguing process. As long ago as April, 1950, the Council set up a Special Committee, under the chairmanship of Mr. Burke, to study the question of the reorganisation of the Institution. The Committee's Report was published in October, 1951, and accepted by the Council in April, 1952.

The Council had then charged the Finance & General Purposes Committee with redrafting the Articles of Association with two main objects in view. The first was to implement the recommendations of the Burke Report, and the second was to put them in such a form as was thought would facilitate the eventual application for a Royal Charter. The re-writing of the Articles was finally completed, and after a great deal of discussion in the Sections and by the Council, the revised Articles were approved and accepted by the Council. They had also been approved, with some minor alterations, by the Board of Trade.

With regard to regionalisation, that matter had specifically been left open in the new Articles, which did not specify the boundaries or the names of the Regions. Similarly, they did not specify the organisation of any Region, and they did not bind anybody to any particular process or routine within the Regions. All they did was to lay down that in the British Isles there would be twelve Regions and the Council could then settle the boundaries and the names of the Regions as they wished. Alterations could be made at any time without changing the Articles and without consulting the Board of Trade. When the Regions were set up, they could themselves decide just how the organisation of a particular Region should work. There would be a wide difference between Regions which could be very closely integrated, such as those in the Midlands, and the Regions which would do no more than meet perhaps once a year, but it would be for them to decide which of the Section Chairmen would be the Regional Chairmen, and how the particular capitation for the Region would be distributed amongst the Sections.

Mr. R. E. Leakey, President of the London Section, said that his Committee had had some misgivings regarding some sections of the Articles, but now felt assured that those responsible for the redrafting had been well advised.

Mr. H. Tomlinson seconded the motion, which was carried with two members voting against.

Mr. S. G. Haithwaite, President of the Yorkshire Section, assured the meeting that while Yorkshire had registered a protest against the new constitution, now that it had been adopted their wholehearted support could be expected.

Election of Members to Council

The Report on the Election of Members to Council was received on the motion of Mr. J. Blakiston, seconded by Mr. J. E. Hill.

Annual Report of Council

The President proposed that the Annual Report be taken as read, and asked Mr. G. R. Pryor, in the absence of Mr. H. Burke, to speak to the Report.

Mr. Pryor said he had nothing to add to the Report as published in the January, 1954, Journal, except to assure members that any questions they might raise would be answered. He moved the adoption of the Annual Report of Council.

Mr. E. N. Farrar seconded, and the Annual Report was adopted.

Statement of Income and Expenditure, Balance Sheet and Auditors' Report

Mr. G. R. Pryor moved the adoption of the accounts. The motion was seconded by Mr. T. Fraser, C.B.E., and carried unanimously.

Election of Auditors, 1953/54

On the motion of Mr. E. Percy Edwards, seconded by Mr. R. Hutcheson, Messrs. Gibson, Appleby & Co., Chartered Accountants, were re-elected Auditors to the Institution and thanked for their services.

Election of Solicitors

Mr. H. Peter Jost moved that Messrs. Syrett & Sons be re-elected Solicitors to the Institution and that they be thanked for their services. Mr. S. G. Haithwaite seconded the motion, which was carried.

Votes of Thanks

The President said he desired particularly to refer to the three Principal Officers in the year under consideration, Sir Cecil Weir, Mr. Burke and Mr. Pryor.

When he left his office as Chairman of Council, he had a feeling of great satisfaction in that he had managed to persuade Sir Cecil Weir, although not much persuasion was needed, to become the President of the Institution. Sir Cecil Weir was a great public servant, a well-known and respected figure among a wide range of public authorities, and a man who had one foot very firmly in the innermost circle of government and the other in free enterprise as members of the Council knew it.

The fact that Sir Cecil Weir was more than willing to become the President of the Institution was a very great mark of esteem as far as the Institution was concerned. It was not long after that when he was asked to undertake even further responsibility and he went to Luxembourg, where he represented this country as a Minister with ministerial rank in charge of the British delegation in what was known as "Little Europe". The President knew himself from the work which Sir Cecil Weir was doing and what Britain's participation was likely to be, how important was his job, and the fact that Sir Cecil Weir was able to undertake that task and, at the same time, give service to the Institution—many members of Council knew how often Sir Cecil came back from Luxembourg to put in an appearance at the Institution's various functions—spoke even more highly of him than was thought possible and that, indeed, was very high. The President desired, therefore, as part of the composite vote of thanks, on behalf of the Institution to record deep appreciation for the great service which Sir Cecil Weir gave to the Institution.

As far as Mr. Burke was concerned, there again the President had some small hand in his selection and the fact that no sooner had he become Vice-Chairman of the Council than Mr. Burke was handed the arduous and difficult task of reorganising the Institution, spoke highly of his ability. He worked enthusiastically through his apprenticeship as Vice-Chairman and became Chairman of the Council, and it was unfortunate that he could not be present so that he could hear publicly what the Council thought of the great work which he had done for the Institution. Speaking personally, the President said he wished to say how much he had appreciated the great help which Mr. Burke had given him in the last few months.

All the work which was to be seen in the January Journal concerning the details connected with the Articles of Association was very largely that of Mr. Pryor, the Vice-Chairman of the Council, with the able assistance, of course, of Headquarters staff. Mr. Pryor represented the Institution on the highest possible level and in a first-class manner.

The vote of thanks to Sir Cecil Weir, Mr. Burke and Mr. Pryor was carried by acclamation.

Mr. Pryor said he was sorry that he was the only one of the three officers to whom the President had so kindly referred who was present to respond. He felt sure it would be the unanimous wish of Council that he should move a hearty vote of thanks to the President, first for conducting the meeting in his usual brisk and able manner and, secondly, for all the other work that he had done. It would also be considered appropriate, no doubt, to couple with that vote of thanks congratulations on the honour which had been bestowed on the President. Mr. Puckey had done so much work for the Institution, was so closely identified with it and had been for so many years that members could all be excused if they took the view that the Institution had been almost equally honoured by the honour bestowed upon its President.

The vote of thanks was carried by acclamation.

The President, in response, said that he was very gratified at the reception accorded to Mr. Pryor's kind references to himself, and the many scores of letters which he had received from members had also been a great source of gratification and delight. He could think of no more appropriate time to receive such an honour than when he was President of the Institution, and if in any way at all it helped directly or indirectly the status of the Institution and what it stood for, then no one would be more delighted than himself.

The proceedings then terminated.

BRITISH STANDARDS

The following Standards have recently been issued and may be obtained post free, at the prices stated from the British Standards Institution, British Standards House, 2, Park Street, London, W.1 :—

B.S. 864 : 1953. Capillary and compression fittings of copper and copper alloy for use with copper tube complying with B.S. 659 and B.S. 1386 (4/-).

B.S. 2051 : Part 1 1953. Copper and copper alloy capillary and compression tube fittings (for use with fractional O.D. sizes of tubes) for engineering purposes (3/-).

B.S. 2060 : 1953. Copper alloy globe valves for general purposes (3/-).

JOURNAL BINDERS

Members are advised that binding cases for the Journal are available, and may be ordered from Head Office. The cases, which are strongly made and covered in dark red leather cloth, with "The Institution of Production Engineers Journal" in gilt on the spine, will each hold 12 copies of the Journal. The price per case is 10/-, post free.

REPORT OF THE MEETING OF COUNCIL

Thursday, 28th January, 1954

THE third Council Meeting of the present Session took place at 36, Portman Square, London, W.1, on Thursday, 28th January, 1954. Mr. G. R. Pryor, Vice-Chairman of Council, took the Chair until the arrival of the Chairman of Council, Mr. Harold Burke, who was delayed by a transport breakdown.

The Meeting was attended by 38 members, and also present were Mr. R. T. Spencer, Chairman, Liverpool Graduate Section, and Mr. J. Taylor, Chairman, Halifax Graduate Section.

Finance

The Institution's financial position was discussed at some length, with particular reference to Section expenditure and the purchase of the new Headquarters. A recommendation by the Finance and General Purposes Committee, setting out certain measures which, if put into operation, would decrease the cost of Headquarters' services to Sections without restricting their activities, was adopted.

Education

The Finance and General Purposes Committee were pleased to report that Dr. W. Abbott, C.M.G., O.B.E., had kindly agreed to act as Honorary Education Advisor to the Institution.

Mr. H. W. Badger, M.A., had been appointed Institution Education Officer and would take up his duties on 29th March, 1954.

Following a special meeting with the President, when the Institution's educational policy was discussed, the Education Committee were now carrying out a careful investigation into all aspects of education for production, and would report their findings in due course.

Summer School, 1954

Council agreed the Education Committee's proposal that this year's Summer School should take as its theme: "Apprentice Training".

New Articles of Association

Following the adoption of the new Articles of Association at the Annual General Meeting, the Finance and General Purposes Committee were empowered to form an Ad Hoc Committee to implement the resulting changes to the Constitution. The new Articles were fully discussed and a number of recommendations made for the attention of the Ad Hoc Committee.

Draft Standing Orders

Standing Orders, to apply where the Articles of Association were not specific, had been drafted and were approved by Council.

Register of Consultants

The Finance and General Purposes Committee reported that it had been decided to maintain at Headquarters a register of Consulting Production Engineers.

New Headquarters

It was reported that work was proceeding in connection with the redecoration and equipping of the new Headquarters, and it was anticipated that the Institution would move into 10, Chesterfield Street in May.

Donations to the Building Fund now amounted to £9,255. Steps were being taken to give further publicity to the Appeal.

Institution Papers

The Secretary reported that the George Bray Memorial Lecture and the Viscount Nuffield Paper had both been successfully inaugurated during the last quarter. Reports of the Meetings, together with the Papers delivered, were being published in the *Journal*.

Production Conference and Exhibition, 1954

The Special Committee dealing with the organisation of this project had met several times since the last Council Meeting, and arrangements were proceeding. Details were being circulated to members with the February, 1954, issue of the Journal.

Membership

Council adopted a recommendation from the Membership Committee that candidates who were otherwise "Not Qualified" should be given permission to sit for the Institution's Associate Membership Examination, provided that they were informed in writing (a) that the passing of the Examination did not, of itself, qualify the candidates for membership, and (b) what further qualifications such candidates would need to qualify for election.

Applications for Membership and Transfer

Council approved a number of applications for membership and transfer. Particulars appear on pages 190 and 191.

The Journal

The Editorial Committee were pleased to report that the net revenue accruing to the Institution from advertising in the Journal during the twelve months ending December, 1953, was in excess of the estimated figure. This had enabled the Committee to publish more editorial matter and so maintain a satisfactory balance between editorial and advertising matter.

The Papers Committee were pleased to report that The Rt. Hon. the Earl of Halsbury, Managing Director of the National Research Development Corporation, had accepted the Institution's invitation to present the 1954 Sir Alfred Herbert Paper. It had been arranged with the Organising Committee that this Paper should be presented at the opening session of the Production Exhibition and Conference at Olympia on July 7th, 1954.

Research

It had been decided to reconstitute the Materials Handling Sub-Committee and the Research Committee had recommended that their future researches should relate to materials handling within the factory, attention being given to factory layout and the "unitisation" of packs.

The Materials Utilisation Sub-Committee were nearing the end of their investigations and it was hoped that a Report would be available in the early autumn.

The Production Control Sub-Committee had been working closely with the Works Statistics Sub-Committee of the Institute of Cost and Works Accountants, and it had been agreed that a Joint Report would be issued.

Standards

The Standards Committee were continuing their work of commenting on draft B.S.I. Specifications, and nominating Institution members to serve on B.S.I. Technical Committees. An article on standardisation, by the Chairman of the Standards Committee, Mr. C. M. Holloway, would appear in the April, 1954, Journal.

The Library

Arrangements were proceeding for the Conference at Cranfield on 2nd/5th April, 1954, on "Information and the Production Engineer", in which the Institution was collaborating with the Engineering and Aeronautical Groups of Aslib.

The Library Committee expressed their great appreciation of offers of help with abstracting and reviewing of books.

Local Section Reports

Council received the Local Section Reports, extracts from which appear on pages 192/195.

Honours

On the motion of Mr. J. E. Burnett, seconded by Mr. R. E. Leakey, Council recorded with considerable pleasure that Her Majesty the Queen had conferred the award of Knight Bachelor upon Mr. Walter Puckey. The motion was carried by acclamation.

Council were also pleased to record awards to the following members:—

C.M.G.—N. C. Robertson, Affiliate Representative
C.B.E.—Miss A. G. Shaw, M.I.Prod.E.
O.B.E.—A. J. Perkins, M.I.Prod.E.
MB.E.—G. H. Rippon, M.I.Prod.E.
J. Hastings, A.M.I.Prod.E.

Obituary

Council recorded with regret the deaths of the following members:—

Members

R. W. Bedford; G. W. Clarke; Capt. F. D. H. Ronald; B. C. Tilghman.

Associate Members

W. R. Bryant; J. Wilson.

Date and Place of Next Meeting

Thursday, 29th April, 1954, at 11 a.m., at 36, Portman Square, W.1.

ELECTION OF MEMBERS

28th January, 1954

ADELAIDE SECTION

AS ASSOCIATE MEMBERS
L. G. Curtis, F. T. Jones

BIRMINGHAM SECTION

AS ASSOCIATE MEMBERS
R. H. Pye, G. M. Ranson.
AS ASSOCIATE
E. Carpenter.
AS GRADUATES
T. R. Blewitt, H. E. Furness, N. K. Ghosh, B. P. Hayward, W. A. Leach, I. W. Readman, G. H. Robinson, J. E. Scott, P. G. Slamer, G. H. Trengrouse, H. B. Webster, F. M. Whittaker, E. Wilkes, R. Willis.
AS STUDENTS
M. J. Davies, P. Hayward, D. R. Haywood, B. E. Heselton, P. C. Higgins, J. A. Hitcham, D. C. Newton, J. Smith, G. V. Wardroper, A. G. Willis.
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBER
L. W. Bell, G. Dixon, G. R. Gluck, J. A. Greatorex, D. H. Smith, J. L. Stephens, M. C. M. Unitt.
FROM STUDENT TO GRADUATE
M. J. Harvey.

BOMBAY SECTION

AS ASSOCIATE MEMBER
J. B. Emmerson.
AS STUDENT
A. V. Pandit.
TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
S. G. Barbet.

CALCUTTA SECTION

AS MEMBER
S. J. Shahaney.
AS ASSOCIATE MEMBER
P. H. Bhanot, A. D. Foster, C. C. Rao.
AS GRADUATE
S. Nath Kundu.
AS STUDENTS
S. Bhattacharji, M. Gupta, V. S. Rama Swamy.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
A. E. E. H. Davison.
FROM STUDENT TO GRADUATE
R. Datta.

COVENTRY SECTION

AS MEMBER
F. T. Hill.

AS ASSOCIATE MEMBERS
K. A. Burton, J. E. J. Chignell, E. E. Shephard.
AS GRADUATES
G. A. Chaudhry, A. J. Fletcher, C. P. Sanders.
AS STUDENTS
B. Johnson, J. E. Lloyd, J. B. Tyler, S. H. Villiers.
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBER
R. Clarkson, E. R. Unitt.
FROM STUDENT TO GRADUATE
J. M. Caunt, B. J. Orr.

DERBY SECTION

AS ASSOCIATE MEMBER
C. H. Walters.
AS GRADUATE
G. P. Piper.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
K. E. Limbert.

DUNDEE SECTION

TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
C. F. Seymour.

EASTERN COUNTIES SECTION

AS ASSOCIATE
J. F. A. Mancer.

EDINBURGH SECTION

AS STUDENT
D. A. Bowman.

GLASGOW SECTION

AS ASSOCIATE MEMBERS
W. Bailey, F. A. Checkley.
AS GRADUATES
D. A. J. Adger, S. J. Carne, M. Naddell D. Nicolson, J. Thomson.
AS STUDENTS
J. D. Hughes, E. C. Walker.
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBER
J. F. Gray.
FROM STUDENT TO ASSOCIATE MEMBER
W. B. McLarty.
FROM STUDENT TO GRADUATE
R. Carrie.

HALIFAX SECTION

TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
G. H. Brook.

LEICESTER SECTION

AS ASSOCIATE MEMBERS
G. S. Cope, A. B. Greene.
AS GRADUATES
S. B. Chanda, E. Pearson.
AS STUDENT
E. B. Thain.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
P. Griggs, R. D. Owen.

LINCOLN SECTION

AS ASSOCIATE MEMBER
W. Pocklington.
AS STUDENT
D. Robinson.

LIVERPOOL SECTION

AS ASSOCIATE MEMBERS
R. Carrington, J. Robinson.
AS STUDENTS
K. A. Edwards, T. N. Parr.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
J. J. Farley.

LONDON SECTION

AS MEMBER
R. S. Geoghegan.
AS ASSOCIATE MEMBERS
G. Drake, G. Kenyon, H. E. Roe, M. N. Stark T. Stuchbery, W. R. Vaughan.
AS ASSOCIATE
P. W. Yates.
AS GRADUATES
T. G. Howe, D. E. Jarvis, A. F. Jordan, J. Rawicz-Szczerbo.
AS STUDENTS
G. A. W. Bryant, D. J. Gascoyne, N. G. Hine, D. G. T. Hyde, B. F. Kirk, L. A. G. Linden.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
Miss K. M. Cook, C. H. Taylor-Cook.
FROM INTERMEDIATE ASSOCIATE MEMBER TO ASSOCIATE MEMBER
P. R. Austin.
FROM GRADUATE TO ASSOCIATE MEMBER
P. F. Cornell, L. B. Dove, L. E. Overton, J. I. Willmore.
FROM STUDENT TO GRADUATE
E. A. Brooks, B. L. Harris, R. C. C. Wadey.

LUTON SECTION

AS ASSOCIATE
F. I. Mutditt.
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBER
H. J. Aldridge.
FROM STUDENT TO GRADUATE.
F. W. Wray.

MANCHESTER SECTION

AS ASSOCIATE MEMBER
J. H. Heaton.

MELBOURNE SECTION

AS MEMBER
F. Price.
AS ASSOCIATE MEMBER
T. A. Cracknell.
AS STUDENTS
R. Arthur, D. F. A. McKelvie.

NEW AFFILIATED FIRMS	NEW AFFILIATED REPRESENTATIVES
The Sheffield Corp. of Aust. Pty. Ltd.	R. Chaney, A. E. Swalwell.
The Steel Improvement Co. Pty. Ltd.	R. H. E. Atkin, J. E. Gaskell.

NORTH EASTERN SECTION

AS MEMBER
W. H. Mather.
AS ASSOCIATE MEMBER
W. Graham.
AS STUDENT
G. Loebl.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
W. York.

NOTTINGHAM SECTION

AS ASSOCIATE MEMBERS
E. V. Carter, M. Fleming.

OXFORD SECTION

AS ASSOCIATE MEMBERS
A. E. Baxter, R. Lamb.

PRESTON SECTION

AS STUDENT
K. J. Miller.
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBER
B. G. Green, R. T. Hurst, O. Laycock.

READING SECTION

AS MEMBER
J. M. Lyden.
AS ASSOCIATE MEMBER
Lt.-Col. H. Cliff.

ROCHESTER SUB-SECTION

AS STUDENTS
J. H. Ely, J. K. Liddle.

SHEFFIELD SECTION

AS MEMBERS
G. R. Whitehead, W. J. Edgington.
AS ASSOCIATE MEMBERS
F. R. Bradshaw, D. E. Paget.
AS GRADUATE
W. A. Gelder.
AS STUDENTS
D. Grayson, W. M. G. Keeling.
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBER
S. S. Boyce, E. Dobson.

SOUTHERN SECTION

AS MEMBER
L. J. Walker.
AS STUDENT
J. Davies.

SOUTH AFRICA SECTION

AS MEMBER
A. J. Blaschke.
AS ASSOCIATE MEMBER
C. W. J. Cox.
TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
A. Michie.

SOUTH WALES SECTION

AS ASSOCIATE MEMBERS
E. G. Graham-Falcon, E. G. R. Jones, A. E. Smith.
AS GRADUATE
L. Preece.

SOUTH ESSEX SUB-SECTION

AS GRADUATE
E. A. Crisp.
AS STUDENTS
B. A. Pashley, M. G. Townsend.

STOKE-ON-TRENT SUB-SECTION

AS GRADUATE
R. F. Briscoe.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
F. Stafford.
FROM GRADUATE TO ASSOCIATE MEMBER
K. H. Buckley.

SYDNEY SECTION

AS GRADUATES
T. G. Barnes, C. J. Brookes.

WESTERN SECTION

AS GRADUATE
E. A. Freeman.
AS STUDENTS
M. J. Hewitt, B. A. Joyner, J. A. Young.

WEST WALES SECTION

AS ASSOCIATE MEMBERS
W. R. Jones, J. S. McLean.

WOLVERHAMPTON SECTION

AS MEMBER
J. W. Whimpenny.
AS ASSOCIATE MEMBER
E. C. Wakefield.
AS GRADUATES
H. M. Harvey, O. J. Jones.
AS STUDENT
L. J. Morris.
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBER
C. S. Cooper.
FROM STUDENT TO GRADUATE
R. H. Collings, A. Mukherji, D. A. Simkins.

YORKSHIRE SECTION

AS ASSOCIATE MEMBER
A. A. Paget.
AS STUDENTS
D. Brook, E. Fell, V. W. Robinson, K. W. Topliss.
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBERS
J. N. Eady, R. T. Shackleton.
FROM STUDENT TO GRADUATE
B. Cleaver.

NO SECTION

AS MEMBER
F. Preator.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
G. H. Hockley.

R.S.A. ENDOWED PRIZES, 1954

The Royal Society of Arts offers the following prizes during the year 1954:

Benjamin Shaw Prize for Industrial Safety. A prize of £20 is offered "for any discovery, invention, or newly-devised method of obviating or materially diminishing any risk to life, limb or health, incidental to any industrial occupation, and not previously capable of being so obviated or diminished by any known and practically available means".

Fothergill Prize for Fire Prevention or Fire-Fighting. A prize of £20 is offered for a descriptive essay or model embodying some new idea for the prevention or suppression of fire.

Howard Prize for Mechanical Motive Power. A prize of £20 will be awarded to the author of a treatise on some aspect of the subject of mechanical motive power.

Full particulars of these and other awards offered by the Society, together with conditions of entry, may be obtained from the Secretary of the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2.

EXTRACTS FROM LOCAL SECTION REPORTS

Presented to Council, 28th January, 1954.

Birmingham

At the second lecture meeting of this session, Mr. W. H. Hodgetts, M.I.Prod.E., a member of the Section Committee presented a very interesting Paper entitled "The Value of Work Study to Industry". A lively discussion ensued.

In November, Mr. J. Smedley, M.I.Prod.E., and Mr. Warburton from Derby showed, with the aid of many interesting slides, how it is possible to maintain high quality in spite of an insistence for high output, and a good meeting resulted.

At the December meeting a lecture on the latest developments in metal forging techniques was accompanied by a film and the first half of the session's activities terminated with a Buffet Dance at the Botanical Gardens, Edgbaston, in December. The Section is now represented on local productivity committees at Dudley, Worcester and Kidderminster, in addition to the Birmingham Productivity Association.

The A. J. Mansell Fund has been closed at the figure of £360 and the Section President wishes to thank once again all those members who have contributed so generously.

Bombay

In October a most interesting Paper on "The Building of a Coastal Cargo Vessel" was read by Mr. G. L. Brough, M.I.Prod.E. This Paper, which was illustrated by slides, was greatly enjoyed by members and there was a lively discussion. In November a "Quiz" was held, at which members of the audience put questions on general engineering to a team of experts. This meeting was such a success that it is the intention of the Committee to repeat the idea at a meeting next May.

Meetings of the Section Committee and also of the Membership and Activities Sub-Committees have been held during the last three months. Arrangements for the next Annual Dinner to be held in March, 1954, are well advanced.

A publicity and membership campaign has been instituted during the period under review and this has shown encouraging results in interesting prominent firms in the work of the Institution in Bombay.

Calcutta

There were few activities during the months of October and November, most of the members being away on account of the Puja holidays. In December there was a film show on "Resistance Welding" by courtesy of Mr. F. E. Bloomfield, A.M.I.Prod.E. Two Committee meetings were held in October and November.

The Annual Dinner was held in December, Sir Shri Ram being the Chief Guest.

Canada

The 1953/54 lecture programme opened in Toronto in October with the showing of a sound film: "Drop Forging in Closed Dies". This was followed by an interesting discussion led by the Chairman, Mr. C. J. Luby and Mr. J. G. Gill. The film contained much to cause a lively question period and was particularly welcomed as it had not been shown previously in Canada.

In November, Mr. A. W. Millward, A.M.I.Prod.E., presented a Paper entitled "Automatic Turning Machines". A large number of slides and a film were shown followed by a discussion. The talk covered aspects of automatics of all types and manufacture.

The Christmas Dance held in December was thoroughly enjoyed by the many members and friends who attended.

Cornwall

The Section President, Capt. F. W. Spencer, continues to make good progress following a serious operation in the early autumn. Capt. Spencer has been a stalwart in the Section for many years, and members throughout the country will join the Cornwall Section in wishing him a speedy return to good health. Presidential duties are being carried out by Mr. H. M. Sawyer.

The winter programme of lecture meetings commenced in October, when Professor W. D. Seymour of Birmingham University presented a Paper entitled "Industrial Skills". Great interest was shown in this lecture on Work Study. Mr. G. D. Alder, M.I.Prod.E., Principal of the Cornwall Technical College introduced an "Ad hoc" course on Work Study, arrangements for the course being made by Mr. A. Wakeman, M.I.Prod.E., Head of the Engineering Department at the College; Mr. W. G. Hosken, member of the Section Committee, was lecturer-in-charge. The course attracted some 150 people from industry and included many members.

Mr. A. J. White, Wh.Sc., M.Eng., A.I.Mech.E., gave an interesting lecture on "Drop Forging and Stamping" in November and in the discussion that followed he showed a wealth of knowledge and experience in answering many difficult questions.

Coventry

The President of the Institution and members of the Birmingham, Wolverhampton and Shrewsbury Sections were welcomed to the opening meeting of the current session. Prior to the reading of the Regional Paper, "Aircraft Production Development" by Mr. W. A. Sales, O.B.E., Mr. Puckey presented membership certificates to a number of newly-elected members.

The Annual Dinner and Dance held at the Matrix Hall in October was again most successful and enjoyable. The guests included the President of the Institution, the Deputy Mayor and Lady Mayoress of Coventry, and the Town Clerk of Coventry, also Section Presidents of the adjacent Sections.

Coventry Graduate

The October meeting of the Section on "Methods Time Measurement" by Mr. R. L. Webb, Grad.I.Prod.E., stimulated a lively discussion, the meeting being well attended. In November, Mr. N. Stubbs, M.B.E., B.Sc.(Hons.), gave an excellent lecture on "Productivity and the Machine Tool".

The first works visit of the session was held in November, when some thirty members enjoyed a well-organised visit to the English Electric Company Ltd., Rugby.

Eastern Counties

The winter programme of meetings commenced in October with a joint meeting with the Colchester Engineering Society, at which Mr. W. F. Garnham gave a most

interesting talk on impressions of a visit to America as leader of a Productivity Team.

Owing to the indisposition of the Section President, the November meeting had to be cancelled at short notice, and the Presidential Address postponed until December. In his address, which was illustrated by lantern slides, the President described the various types of transport used in an engineering works, and explained some of their uses. His talk concluded with a reference, illustrated by a tape recording of typical radio conversations, to the application of two-way radio to works transport. It is hoped to be able to hold a joint meeting with the Cambridge and District Engineering Socieity in April, 1954.

Glasgow

Three lecture meetings have been held during the quarter; in October, Dr. R. H. Barfield presented a Paper entitled "High Frequency Heating and Induction Hardening"; in November, Mr. S. A. Murray spoke on "Metal Finishing and Hard Coating", and in December the subject was "Maintenance and the Production Engineer", presented by Mr. A. J. MacIntyre, this being a joint meeting with the Institute of Industrial Supervisors. An open discussion on "The Selection and Purchase of Machine Tools" led by Mr. Menzies took place during November.

Halifax

The Halifax Section were represented at the George Bray Memorial Lecture meeting held in Leeds during November.

The three lectures arranged for the first half of the year were very well presented. The various subjects concerning Institution policy are under review and recommendations will be submitted shortly.

Leicester

At the opening meeting of the 1953/54 Session, a large audience heard a Paper on "The Development of Copy Turning" by Mr. L. Lloyd. The November meeting also attracted a large audience, Mr. B. H. Dyson's Paper on "Production Management's Responsibility for Production" provoking much lively discussion.

The Committee Evening given early in December consisted of four brief Papers given by members of the Committee on various subjects connected with Production Engineering. This meeting was well attended and the volume and nature of the questions raised indicates that further meetings of this type should be considered.

Towards the end of November, the Section was privileged to entertain the President of the Institution, the Lord Mayor of Leicester and the Principal of the Leicester College of Technology and Commerce at its Annual Dinner.

Lincoln

The winter session opened in October when Mr. J. E. Hill, M.I.Mech.E., M.I.Prod.E., gave a talk on "Men and Machines". The second meeting was held at Scunthorpe when Mr. C. W. Higgins, A.C.I.S., A.C.C.A., A.M.I.I.A., gave a talk entitled "Planning for Production Incorporating Cost Control".

A Dinner Dance was held in November to celebrate the tenth anniversary of the formation of this Section. The Section were very pleased that the Institution President was able, with his many commitments, to be present. In November, a joint meeting with the Lincoln Branch of the Institution of British Foundrymen was held, and the attendance was very good. Mr. G. R. Shotton, M.I.B.F., M.I.W.M., gave a talk on "Foundry Technique in Relation to the Production Engineer".

London

The loss of Mr. J. E. Burnett, A.M.I.Prod.E., and Mr. W. D. Opher, M.I.Prod.E., from the Section Committee, as they have both left the London area, is regretted. Mr. Opher's resignation has created a vacancy on Council, as he was an additional representative for London, and this vacancy has been filled by Mr. F. G. S. English, M.I.Prod.E.

This Session's programme has so far proved to be highly successful, six lecture meetings having been held to date. Mr. R. Appleby's Paper "Management in the Light Engineering Industry" opened the Session on a very high note, and promoted a most stimulating discussion. At the first Croydon meeting an excellent Paper was given by Mr. A. Emmerson, M.I.B.F., on "Shell Moulding". The combined film and lecture meetings on precision engineering by Mr. R. H. Reddy, gave rise to lively discussion. In November, Mr. G. R. Bell, who had just returned from the U.S.A., gave an excellent lecture on "Powder Metallurgy".

In December at the Brighton meeting, Mr. C. Cooper, A.M.I.Prod.E., A.M.I.I.A., M.I.Ec.E., gave an excellent Paper on the way in which some of the modern administrative and managerial techniques, and methods such as work measurement, standardisation, etc., will promote better production. Also in December, Mr. K. J. Hume, B.Sc., M.I.Mech.E., M.I.Prod.E., gave a Paper on "Gauge Design" which was well attended, and the author put forward a plea that designers should give greater consideration than they do to the incorporation of kinematic mountings for movable parts of gauging equipment at a means for eliminating inherent inaccuracies often found in gauging fixtures.

The Annual Dinner and Dance held at the Savoy Hotel was without doubt, a great success, 400 people being present.

Luton

The quarter under review marks the renewal of interest and activity in the work of the Section. The lecture programme made a good beginning in September with a lecture, illustrated by films, given by Mr. W. Jaye, dealing with precise dimensional measurement.

A development in this year's programme was a joint meeting with the Eastern Branch of the Institution of Mechanical Engineers held at Bedford, at which Mr. J. Cherry lectured on "Some Aspects of Machinability". It is hoped that a joint meeting will be a permanent feature of the programme in future years.

Luton Graduate

Interesting and worthwhile visits were made to Vauxhall Motors Limited, Luton, Gasworks, and to the Houses of Parliament, where the party were fortunate enough to be conducted round by Dr. Charles Hill, M.P. for Luton. The visit to the Houses of Parliament was followed up by an impromptu tour of the Institution's new headquarters in Mayfair with which the party were very much impressed.

The lectures delivered at the meetings have been well received, the subjects being industrial radiography, furnace brazing, and shell moulding.

Manchester Graduate

The President of the Manchester Section, Mr. H. Spencer Smith, M.I.Prod.E., has very kindly offered to award a Section President's Prize to the Student or Graduate who submits the best Paper of the year. The title of the Paper or essay may be chosen from a wide range of subjects, and candidates are informed that it is not a condition of the award that the Paper has to be read at a Section meeting.

It is proposed to send four representatives to the Fourth Annual General Graduate Conference to be held at Coventry in March, 1954. It is hoped this will include two members from the Stoke-on-Trent Sub-Section.

Melbourne

In September, 48 members of the Melbourne Section made a day visit to Ballarat, 70 miles from Melbourne, where they were the guests of M. B. John Ltd., valve manufacturers. After a short tour of the city the members were entertained to lunch by the Directors and later inspected their factories.

At the Annual General Meeting held in October the Section officers for the next session were elected. The

meeting which was attended by 70 members was followed by a Paper on "Pattern Manufacture for Production".

The last function for the year took the form of an Annual Dinner at the Victoria Hotel in November, when 110 members, visitors and guests attended. The Dinner was most successful and not only allowed members to meet their friends in industry but also promoted much goodwill.

North Eastern

The Session opened with an interesting address from the Section President, Mr. H. Henderson, M.I.Prod.E., and Papers from Mr. H. B. Topham, A.M.I.Prod.E., and Mr. T. P. N. Burness, M.I.Mech.E., M.I.Prod.E., on "Lighting and Production" and "The Application of Precision Engineering to the Cutting and Polishing of Gem Diamonds" respectively. The attendance at all three meetings was very good and a vigourous discussion followed the two Papers. In December a Film Evening was held.

Norwich

During the quarter under review two meetings have been held in Norwich. For the opening meeting of the session the Sub-Section was honoured by a visit from Mr. H. Burke, Chairman of Council, whose address entitled "The Institution and You" was much appreciated. In November, Mr. K. W. Abineri gave a Paper, illustrated by slides, on the subject of "Modern Industrial Finishing Processes" which also aroused considerable interest.

Committee Meetings have been held regularly, one of the main items of business being the arrangements for holding a Conference in Norwich next April on the theme of "Production Engineering Developments".

Oxford

The Oxford Section has held a lecture meeting each month since the Session opened in September with an informal lecture by Mr. F. G. Woollard, M.B.E., on "The Evolution of Flow Production in the Engineering Industries". Original Papers have been presented to the Section on "Blanket Manufacture", on "The Mass Production of Refrigerators", and on "Methods of Increasing Productivity with Existing Equipment".

A local Committee of the British Productivity Council has been inaugurated in Oxford, and the Institution is represented on the Steering Committee by Mr. C. E. Walker, B.Sc., M.I.Mech.E., Head of the Technical College School of Engineering, and a member of the Section Committee.

Reading

The Committees of the Reading, Southern and Oxford Sections met in Reading in November to discuss the setting-up of the proposed Southern Region-Regional Plan.

A Committee member of the Materials Utilisation Sub-Committee visited the Section and a clearer picture of the type of required case studies was given. This Section agreed to submit cases.

It is reported with gratification that attendances to date at Lecture Meetings have been above average.

Sheffield

At the Section Annual Dinner in October, members were very pleased and honoured to welcome the Institution President and the Rt. Hon. Lord Sempill, A.F.C., Hon.M.I.Prod.E. The occasion was very successful, and the visitors were impressed by the messages of the principal speakers.

The Doncaster Sub-Section have held two successful lectures and a very interesting informal discussion meeting. Efforts are now being made to strengthen the acting committee which has done good work in the organisation of the meetings. It is proposed to hold the official Inaugural Meeting in February but details are not yet definite.

The Sheffield Section have been asked to co-operate with the British Iron and Steel Federation Training Department in their study of "Education for Management" and a Sub-Committee was appointed to answer a questionnaire set out by the Sheffield Academic Board. A working party on the subject is being set up and a representative from the Section Committee is to be appointed.

South Africa

At the meeting in October a "Questions, Answers, and Problems" evening was held. Mr. Henry Hayes delivered a Paper in November, entitled "Modern Methods of Forging and Drop Forging" which was supplemented by slides. Messrs. T. Hunter and Swerdlow contributed to the Paper. At the meeting held in December, Mr. G. T. Chawner delivered a Paper on "Aircraft Problems".

A visit was arranged to the works of Messrs. Haggie, Son and Love Limited, manufacturers of stell wire and wire ropes, and was attended by approximately forty members.

The Sub-Council decided to publish in the form of a booklet the proceedings of the All-Day Symposium of "Work Study" held in September. Through the untiring efforts of the President and members of Sub-Council, the production of the publication will be completed shortly.

Southern

The Southern Section have held three most successful lectures so far this winter, two at Southampton, and one at Portsmouth. As already reported in the February, 1954, Journal, an Aircraft Conference was held at Southampton University in December. The joint lecture activities that have comprised the programme so far this year have been most successful ventures.

Two members of the Southern Section Committee are participating in the British Productivity Council Activities. Mr. H. W. Denny, M.I.Prod.E., is chairman of the Portsmouth Committee, and Mr. J. W. Taylor, M.I.Prod.E., is honorary secretary of the Southampton Committee.

South Essex

Four meetings have been held since September and in all cases have been well attended. Mr. Mustard accepted the Committee's invitation to represent the Graduates on the Committee.

The Committee have been maintaining contact with the local British Productivity Committees in various areas and have promised their support.

Arrangements are being made to supply the Materials Utilisation Sub-Committee with some case studies from Companies in the area.

Stoke-on-Trent

During the period under review Committee meetings have been well supported and there has been a good attendance at lecture meetings.

The Chairman, Mr. H. Porter, M.I.Prod.E., who is a member of the Steering Committee of the North Staffs Regional Board of the British Productivity Council, has kept the Sub-Section Committee informed of developments. Although there has not been such a good response for representation of industry, it is hoped that interest will be fostered and greater support given to the project.

Material Utilisation has been discussed at several Committee meetings, two case studies being presented.

Sydney

The September lecture was given by Mr. G. P. Taylor, B.Sc.(Chig), B.A.Sc.(Toronto). The subject "Technical College Courses" was very ably presented and an interesting discussion followed. The Annual General Meeting took place in October, when Mr. Dennis Ironside presented a Paper on "Technical Application of Stellite in Industry".

The resignations of Messrs. S. E. Barratt, E. C. Parkinson, C. E. Jones, and J. H. Blunt, were accepted with regret. They have all served a long period in office, and have rendered much valuable service to the Section since its inception.

The first Annual Dinner was held in November and 125 members were present. As it coincided with the Australian Sub-Council Meeting the newly-elected President, Mr. J. N. Kirby was able to address representatives from all States. Mr. J. E. Hill, Past Chairman of Council, was also present. (See report on page 197.)

Western

The lectures given to the Western Section during the first three months of the 1953/54 session have all been of a very high order. The session opened with an address on

Management by Sir Ewart Smith which attracted a large audience. This was followed by two technical Papers, the first by Mr. N. R. Laban, B.Sc., A.R.I.C., concerning protective coatings, and the second by Mr. L. C. Hackett and Mr. A. N. Attwood on "Tube Manufacture and Manipulation".

West Wales

The 1953 Programme began well with the showing of five outstanding industrial films. Interest was maintained too for the Paper on "Noise and Vibration" by Dr. W. A. Tuplin. The talk on "Leadership" by Major-General K. C. Appleyard, C.B.E., T.D., D.L., J.P., was received with exceptional enthusiasm by a large and widely representative audience. Attendance at these meetings is a sure indication of the growth of interest in the activities of the Sections, and this has been supported by excellent press reports.

The Section are indebted to Committee Member, Mr. J. S. Hopkinson, A.M.I.Prod.E., and his associates for the visit to the Anglo-Celtic Watch Company. A visit to the Incandescent Heat Company at Smethwick was of outstanding technical interest.

Committee member Mr. W. Williams, as Liaison Officer, has ensured the full consideration of the Institution's Regional Policy and allied matters between this and other Sections immediately concerned.

The last of the committee meetings for 1953 was well appreciated by the Committee, as they were entertained to dinner by the Section President. This was followed by a discussion on the progress and future prospects of this Section and the Institution.

Wolverhampton

A very interesting lecture was given in October by Mr. H. W. Hunt, a local industrialist. It had been arranged for Mr. Player to give the November lecture, but unfortunately he was unable to attend, and a lecture was given by Mr. J. H. Hobbs, on "Inspection as an Aid to Production". The December lecture was given by Professor T. U. Matthew, M.Sc., M.I.Prod.E., on the subject of "Human Relations in Iudustry in Industry". The lecture was very well attended by members and visitors.

The Section had been asked to provide a representative to serve on the Production Engineering Advisory Committee for Wolverhampton and Staffordshire Technical College, and Mr. L. W. Farrer has agreed to represent this Institution.

There have also been requests for representatives of the Section to serve on local Productivity Committees. Mr. A. J. Aiers, M.I.Prod.E., has agreed to represent the Institution on the Wallsall local Productivity Committee, and Mr. W. B. Pamment, A.M.I.Prod.E., A.I.I.A., on the Wolverhampton Local Productivity Committee.

A very successful dance was held in the Wulfrun Hall in December, in conjunction with the Graduate Section.

Wolverhampton Graduate

During the past three months the Graduate Section activities have covered a very wide field of Production Engineering subjects. A lecture on "Modern Cutting Tools and Machine Tool Design" was given by Mr. C. H. A. Welch in October. In November, Mr. J. L. Williams, A.M.I.Mech.E., M.I.W., gave a lecture on "Power Press Design", and in December a lecture was given by Mr. J. G. Campbell on "Surface Broaching". These lectures proved to be of interest and lively discussions followed. Several works visits were made during the period under review.

Worcester

The Inaugural Meeting was held in September when the Section Chairman, and Chairman of Council, together with 72 members and their guests, heard the President of the Institution, outline the history of the Institution from its inception, and in conclusion, he indicated his views on how the Institution should proceed in their service to Production Engineering. Prominent local industrialists contributed to the toasts. (See also p. .)

In October, Mr. B. G. L. Jackman, M.I.Prod.E., M.I.I.A., Section Chairman, presented his Paper on "The Economic Aspects of Increased Productivity", and in November, Professor T. U. Matthew, M.Sc., M.I.Prod.E., presented his Paper on "Production Methods used in the American Automobile Industry".

Yorkshire

The first George Bray Memorial Paper was presented to the members of the Yorkshire, Sheffield, and Halifax Sections in November at the University of Leeds, by Sir Harry Pilkington.

The Chair was taken by the President of the Institution, who was supported by Major-General K. C. Appleyard, Mr. S. G. Haithwaite, Mr. F. T. Nurrish, M.B.E., Major G. I. Bray, Major J. A. H. Bray, and Mr. W. F. S. Woodford. It was agreed that the meeting was an outstanding success.

All meetings held during the period have been well attended.

Yorkshire Graduate

The winter programme commenced with a very interesting lecture on "Methods Time Measurement", by Mr. R. L. Webb, Grad.I.Prod.E., followed by an active discussion. In October, a joint Brains Trust meeting was held with the Halifax Graduate Section. An interesting Paper was read in October by Mr. R. S. Cracknell, Grad.I.Prod.E., on "Work Study with Special Reference to the Clothing Industry". A very lively discussion followed.

At the January Committee Meeting it is hoped to elect new members to bring the number up to strength. Mr. W. Hargreaves has left to join the Forces. Some very useful Committee work has been undertaken by Mr. F. Renwick, who is now leaving the district. Mr. S. K. Ganguly has been a very popular and keen member of the Section during his stay in England, and he now returns to India with the Section's best wishes.

RESEARCH PUBLICATIONS

A number of copies of the following Research publications are still available to members, at the price stated:

Report on Surface Finish, by Dr. G. Schlesinger	15/6
Machine Tool Research and Development	10/6
Practical Drilling Tests	21/-

These publications may be obtained from the Production Engineering Research Association, "Staveley Lodge", Melton Mowbray, Leics.

"AS THE SPIRIT MOVES"

Copies of the above publication, which consists of illustrated Case Studies in Materials Handling gathered together by the Materials Handling Sub-Committee of the Institution in conjunction with the British Productivity Council, may be obtained from the Secretary, 36, Portman Square, London, W.1, price 2/6d. per copy, post free.

INSTITUTION NOTES

HONOURS

In addition to the members mentioned in last month's Journal as having received awards in the New Year's Honours List, the Institution is pleased to record that Mr. N. C. Robertson, M.B.E., was awarded the C.M.G.

Mr. Robertson is the affiliate representative for E. K. Cole Limited.

MEMBERS TO ADVISE INDIAN GOVERNMENT

Two members of the Institution, Mr. J. D. Scaife, a Founder Member and Past President, and Mr. A. B. Lloyd, Associate Member, have arrived in India to advise the Indian Government on methods of obtaining increased production from industry.

Under the Colombo Plan Technical Co-operation Scheme, H.M. Government were asked to provide two British experts, one in foundry operation and one in the machine tool industry, to assist a Committee set up last year by the Government of India to investigate ways and means of increasing production, and Mr. Scaife and Mr. Lloyd will carry out this work.

Mr. Scaife, who was formerly Joint Managing Director of John Lund, Ltd., and is now an advisor on reconstruction and production engineering, and Mr. Lloyd, who is Sales Director of F. H. Lloyd & Co., will spend three months in India visiting foundries and machine tool factories all over the country.

MR. M. C. GARRINGTON

Mr. M. C. Garrington

Mr. M. C. Garrington, Associate Member, has recently been appointed Production Director of Dowty Fuel Systems Limited, one of the Companies of the Dowty Group. Mr. Garrington joined the Company about four years ago as Production Engineer (Fuel Systems) and was later appointed Superintendent of Experimental Manufacture. Last year he made two successful visits to U.S.A. in connection with Dowty equipment made there under licence.

NEW AUSTRALIAN PRESIDENT

Mr. J. N. Kirby

Mr. J. N. Kirby, the recently elected President of the Australian Sub-Council, is a prominent industrialist and well-known member of the Sydney Section. He is Chairman and Managing Director of James N. Kirby Holdings Pty. Ltd., and four subsidiary companies. In 1938 Mr. Kirby was appointed to a Commonwealth Government Sub-Committee to investigate aircraft manufacture in Australia and subsequently was appointed Manager of the Commonwealth Aircraft Company in Sydney. Later, he led a mission to England to study the manufacture of Rolls-Royce Merlin engines.

In addition to the activities surrounding the Kirby organisations, Mr. Kirby is also associated with a number of other companies in Australia. He is Chairman of Directors of International Products Ltd. and its three subsidiaries, and has been Technical Director of Nuffield Australia Pty. Ltd., since its inception in 1946. He is also Vice-Chairman of Conveyancer Fork Trucks (Australia) Pty. Ltd., and a Director of Tecnico Ltd. and its subsidiaries.

Mr. Kirby is a foundation member of the Institute of Metals, Australia, and of the Australian Institute of Management. He is also a member of the Council of the University of Technology, N.S.W.

MR. D. F. HORNE

Mr. D. F. Horne, M.B.E., Member, Group Production Engineer of British Optical and Precision Engineers since 1948, has been appointed to the Board of British Acoustic, one of the companies within the Rand group of equipment manufacturers. Mr. Horne's previous experience was in the aircraft industry, where after practical workshop training, he held positions as Chief Jig and Tool Designer, Chief Planning Engineer, Production Controller, Production Engineer and General Manager.

Mr. Horne is an Associate Fellow of the Royal Aeronautical Society.

SYDNEY SECTION DINNER

The Sydney Section of the Institution held its first Annual Dinner at "Amory", Ashfield, Sydney, on Thursday, November 5th, and 125 members and friends enjoyed a most successful evening.

The Guest of Honour was Mr. R. B. Hipsley, B.E., President of the Metal Trades Employers' Association Among the many personalities present were Mr. John Hill, a Vice-President of the Institution and Member of London Council; Mr. A. W. Timms, of Lockheed Hydraulic Brake Co., England; Mr. Van Exham from the Remington Co., U.S.A. The newly elected President, Mr. J. N. Kirby, spoke briefly on industry in Sydney at present as contrasted to pre-war. Other Members of the Australian Sub-Council present were Mr. H. G. Sutton and Mr. R. Deutsher of Melbourne and Mr. J. H. Law and Mr. W. Gwinnett of Adelaide.

Mr. J. E. Strick, President of the Sydney Section, proposed the toast to the retiring Committee Members, Messrs. J. H. Blunt, S. E. Barratt, C. E. Jones and E. C. Parkinson. These members had devoted considerable time and effort to Institution affairs, Mr. Barratt, Mr. Blunt and Mr. Parkinson being founder members. Mr. Strick expressed to them the appreciation of all members and said that the work that they had done was the basis of the sound foundation on which the Institution in Australia rested today.

The toast to the guests was proposed by Mr. E. G. Bishop, Past Sydney Section President, who welcomed official guests and the guests of members.

Mr. S. E. Barratt proposed the toast to the Institution to which Mr. C. E. Jones replied. In conclusion, Mr. E. C. Parkinson responded to the toast to the Retiring Committee Members. He drew particular attention to the place of the production engineer in the community and his affect on living standards, throughout the world.

The Dinner was extremely successful in every respect and all look forward to the establishment of the function as an annual event.

London Section Dinner-Dance

Over 400 members and guests attended the highly successful Dinner and Dance held by the London Section in January last, at the Savoy Hotel. This photograph shows the Section President, Mr. R. E. Leakey, Works Director of E.M.I. Ltd., and Mrs. Leakey, (right) receiving the immediate Past President, Mr. R. Kirchner, and Mrs. Kirchner.

This photograph taken at the first Annual Dinner of the Sydney Section shows (*left to right*) the guest of honour, Mr. R. B. Hipsley, Chairman of the Metal Trades Employers' Association; Mr. J. E. Strick, President of the Sydney Section; Mr. E. G. Bishop, Past President, Sydney Section and member of the Section Committee; Mr. J. N. Kirby, President, Australian Sub-Council; Mr. S. Downie, member of Sydney Section Committee; Mr. J. Ogden, Vice-President, Sydney Section; Mr. J. E. Hill, a Vice-President of the Institution and Member of Council; and Mr. J. H. Law, Chairman of the Australian Sub-Council.

The inaugural meeting of the Worcester Sub-Section, held last September, was attended by a number of prominent local industrialists and senior members of the Institution.

Above (right): Mr. Harold Burke, Chairman of Council, gives a luncheon address. On his right are Mr. B. G. L. Jackman, Birmingham Section President, and Sir Walter Puckey, President of the Institution, with Lady Puckey.

Top (left): Mr. R. Wheeler, Section Hon. Secretary, and Mr. R. H. Higgs, Section Chairman. Bottom (left): Mr. J. A. Hannay, a founder member of the Institution, gives some friendly advice to the President and to the Secretary of the Institution, Mr. W. F. S. Woodford.

EASTERN COUNTIES PRESIDENTIAL ADDRESS

In December last, the Eastern Counties Section President, Mr. E. N. Farrar, gave his Presidential Address to the Section. The photograph below shows Mr. Farrar with members of the Section Committee, after the meeting. Left to right are: Mr. H. H. Dawson; Mr. S. L. Cook; Mr. L. A. Childs; Mr. A. B. Brook (Section Hon. Secretary); Mr. R. H. Pope; Mr. Farrar; and Mr. F. T. Dyer (Section Vice-President).

NEW APPOINTMENTS

Mr. N. L. Akerman, Associate Member, has been appointed technical representative in Yorkshire for Dean Smith & Grace Limited, Keighley. Mr. Akerman was formerly Leeds Branch Manager for Burton Griffiths Company Ltd. (B.S.A. tools Group).

Mr. F. L. Barker, Associate Member, has now relinquished his appointment with the Ford Motor Company to take up a position as Production Engineer with the Pyrene Company of Brentford.

Mr. P. Bhattacharji, Associate Member, has recently been appointed General Manager of Messrs. Burn & Co. Ltd., Howrah Ironworks, Howrah.

Mr. K. L. Brookfield, Associate Member, has recently relinquished his post as Lecturer responsible for Management Studies at Oxford to join I.C.I. as Work Study Officer in the Dyestuffs Division.

Mr. F. A. Clements, Associate Member, has taken up an appointment as Works Manager with Robert Boby Limited.

Mr. J. Cotterell, Associate Member, has recently been appointed Principal of the new Llandaff Technical College, Cardiff.

Mr. A. Devlin, Associate Member, is leaving this country to take up special duties for his firm, Messrs. Geo. Cohen Sons & Co. Ltd., the "600" Group. His position will be Technical Representative Machinery and Power Plant (Export Division), and he will spend about twelve months in the Far East. Mr. Devlin would welcome the opportunity of meeting any members who may be operating in Singapore or adjacent territory.

Mr. G. C. Fairbanks, Associate Member, has been appointed Deputy General Manager (Production) of Elliott Brothers (London) Limited. Mr. Fairbanks has been for the last six years both Production Manager and later Works Manager of the Lewisham Works. He is now, however, responsible for the production at the factories at Rochester and Borehamwood.

Mr. E. A. Gordon, Associate Member, has recently been appointed Engineer of Manufacture, Rectifier Division, Standard Telephones and Cables Limited.

Mr. A. Houlton, Associate Member, has recently been appointed Sales and Engineering Manager of the Scottish Branch of Purdy Machinery Co. Ltd.

Mr. F. L. Jenkins, Associate Member has now been transferred to the Ordnance Factory at Katni, M.P., India, as Superintendent.

Mr. F. L. Jenkins, Associate Member, has now been cently been made a Director of Churchill-Redman Limited, Halifax.

Mr. F. Mountifield, Associate Member, has recently been appointed Works Manager of Mervyn Instruments Limited.

Mr. S. Pearson, Associate Member, has now been appointed Assistant Lecturer (Grade B) at Wolverhampton and Staffordshire Technical College.

Mr. R. W. Atkinson, Graduate, formerly Section Leader of the Planning Department, has been appointed Assistant Chief Production Engineer at the Projectile & Engineering Co. Ltd.

Mr. J. B. Clapham, Graduate, is leaving this country to take up a position as Applications Manager for Australia and New Zealand for his Company, Messrs. J. W. Roberts Limited.

Mr. N. J. Elander, Graduate, has now taken up a position as Assistant Planning Engineer with the Technical Engineering Division of the Metal Box Company Limited, Willesden.

Mr. R. Marshall, Graduate, has taken up a position as Tool Designer with Marconi's Wireless Telegraph Co. Ltd., Basildon.

Mr. J. P. Mellors, Graduate, has recently relinquished his position as Designer Draughtsman with Orwood Tools Limited to take up a position with W. & T. Avery Limited as Production Designer.

Mr. J. E. Poulter, Graduate, has now been appointed Works Superintendent of the Lambeth Works of Doulton & Co. Limited.

Mr. Eric S. Slater, Graduate, has recently taken up an appointment as Production Development Engineer with Wilmot Breedon Limited, Birmingham.

Mr. Gerald Smith, Graduate, has been appointed General Manager (Padiham Works) of Greenbrook Engineering Co. Ltd.

Mr. P. F. Thorpe, Graduate, has taken up a position as Assistant Works Manager with J. & E. Arnfields Limited, Audenshaw, Manchester.

Mr. S. D. Whitehead, Student, the son of Mr. F. Whitehead, a past President of the Liverpool Section, has recently left this country for Johannesburg where he is taking up an appointment as Chief Draughtsman with Milners Safe Company (Africa) Pty. Limited.

NEW BUILDING FUND APPEAL

Since the publication of the last list, donations have been received from the following subscribers. (This list was compiled for press on 19th February, 1954.)

L. W. Ballard, A.M.I.Prod.E.
R. B. Bristoll, Stud.I.Prod.E.
R. M. Buckle, M.I.Prod.E.
J. Butler, M.I.Prod.E.

A. G. Crossland, Stud.I.Prod.E.

A. J. S. Dadson, A.M.I.Prod.E.
B. E. Downs, A.M.I.Prod.E.
B. H. Dyson, M.I.Prod.E.

W. N. Ellerby, M.I.Prod.E.
English Electric Co. Ltd.
R. M. Evans, M.I.Prod.E.

P. J. Gibbons, A.M.I.Prod.E.

T. Hardie, A.M.I.Prod.E.

W. T. Keeble, A.M.I.Prod.E.

A. MacNiven-Brown, M.I.Prod.E.

Marsden & Shiers Ltd.
E. Marslend, A.M.I.Prod.E.
A. McDonald, M.I.Prod.E.

E. C. Nicholson, Grad.I.Prod.E.

H. P. Stern, Stud.I.Prod.E.

M. H. Taylor, M.I.Prod.E.

F. W. Whitehead, M.I.Prod.E.

HAZLETON MEMORIAL LIBRARY

Members are asked to note that the Library will normally be open between 10 a.m. and 5.30 p.m. from Monday to Friday each week. The full facilities will not be available at the following times during the month :—

Thursday, 11th March from 11.0 a.m.
Wednesday, 24th March from 12.0 p.m.
Tuesday, 16th March from 2.30 p.m.

It would be helpful if, in addition to the title, the author's name and the classification number could be quoted when ordering books.

REVIEWS

658.58 MAINTENANCE

"Plant Maintenance Conference," *No.* 3, *Philadelphia,* 1952. Techniques of Plant Maintenance, 1952: Proceedings of the Technical Sessions (sponsored by the A.S.M.E. and the S.A.M.), held . . . with the third Plant Maintenance Show, Philadelphia . . . 1952. *New York, Clapp & Poliak Inc.,* 1952. 182 *pages.* £3. 10. 0.

This work represents a complete transcription of 22 lectures delivered at the third Plant Maintenance Conference in Philadelphia during January, 1952, and includes all questions put to the speakers and their spontaneous replies. It shows how the Plant Maintenance Department can effectively contribute to increasing productivity and gives a convincing argument to show that "preventive maintenance" is "productive maintenance".

The basic theme of the Conference is summed up in the term "preventive maintenance", and the papers deal with administrative and practical aspects in an authoritative manner. The authors, each of whom is obviously well qualified in his particular sphere, represent a wide range of industries and for this reason the book should appeal to all Works Managers, Plant Engineers, and Production Engineers, regardless of the specific product with which they may be concerned.

Numerous organisation charts, graphical records and record cards are reproduced to illustrate the text and whilst it is appreciated that they refer in the main to systems employed by the larger American industrial concerns, it is felt that many of the principles could be successfully applied in our own factories.

Some of the more specific and practical aspects of plant maintenance are dealt with under such headings as: "How to Maintain Plant Buildings", "How to Maintain Electric Equipment", "Maintenance in Chemical Plant", "Lubrication" and "Maintenance in an Automobile Plant", whilst from an administration standpoint there is food for thought in the sections relating to the analysis, reduction and classification of maintenance costs and on general maintenance problems.

D.J.J.

658 INDUSTRIAL ORGANISATION: MANAGEMENT

"Principles and Practice of Management" by E. F. L. Brech. *London, Longmans Green,* 1953. 752 *pages. Charts.* £2. 10s.

This work is a comprehensive guide to present-day principles and practices of management. It is edited by the well-known author on managerial matters, Mr. E. F. L. Brech, who supplies the introduction "Management in Principle". In this he sets the tone by discussing not only the nature and background of management, but also by dealing with such diverse matters as management terminology, policy and organisation.

After this general introduction follow the four main sections of the book, each written by an expert in his field. Under the heading "Distribution", various

aspects of sales activities and management, sales planning, distribution channels and various other points of home and export selling are discussed. Reference is also made to the organisation of sales departments and to advertising.

Part 2, "Production", deals with production matters from the establishment of the production division and the design of the product, to the administration of production, e.g., measurement of work, production planning and supervision of production.

"Personnel" is the title of Part 3; it analyses in detail the various aspects of personnel management and industrial relations. An interesting feature of this Part is an example of the procedure of taking a case to arbitration.

Part 4 deals with "Control", and describes an outline of control systems, and then goes into details of various types of budgets and cost control.

Mr. Brech sums up this extensive volume by another contribution which he calls "Management in Practice", in which he deals with such matters as Committees in an organisation, skill in management, and the position of management in the framework of national affairs.

Extensive bibliographies at the end of each part are of great interest to students of management and to practising managers.

There are subjects such as mathematics, law and medicine, where there is a clear line of demarcation between established fact and opinion. The subject of management, however, does not fall into this category, and when reading the "Principles and Practice of Management", one wonders whether, by attempting to produce a comprehensive volume covering practically every aspect of management, whilst at the same time, by necessity, being dependent on the experiences and opinions of the various authors, Mr. Brech has not fallen between the two stools of producing an authoritative reference book on one hand, and a challenging and subjective management book on the other.

This proviso, however, does not detract from the value of the book to Production Managers and Production Engineers. In fact, the "Principles and Practice of Management" will be a valuable addition to any executive's bookshelf. H.P.J.

621.9 MACHINE TOOLS: MACHINING

"Production Engineering for Higher National Certificate, Volume II, Jig and Tool Design" by R. Dent. *London, English Universities Press Ltd.*, 1953. (*Technical College Series*). 227 *pages. Illustrated. Diagrams.* 18s.

Certain limitations make the average student's book of very little use to the owner after he has completed his course. In "Production Engineering Vol. 2" this is not the case. If you are a student, you want to learn how to calculate blank diameters for deep drawing: the examples given in this book are of such a nature that the Jig and Tool Designer will use them as a standard reference.

There are over 220 pages divided into jigs and fixtures, small tools, economics and presswork. It is rather surprising that the book does not conclude with economics and include something about the economics of presswork in this section. It is even more surprising to find auto-cam design in economics. The fact, however, that sections are not quite in order is far outweighed by the very high standard of technical content.

Mr. Dent has, all the time, dealt with fundamentals rather than tried to hold the reader's interest with, perhaps, more spectacular aspects of the subject. His mathematics have been kept as simple and straightforward as possible, but he has not hesitated to use such things as the calculus in economics where it is is really necessary.

The illustrations are clear and a help to the written matter. I would say that the use of knurled thumbscrews on jigs should be altered, representing, as it does, such bad practice.

There are a number of references to Volume I of this work which is concerned with machine tools. In Mr. Dent's foreword he makes no secret of the fact that this book is intended as a comparison to its predecessor. Nevertheless it is almost complete in itself provided the reader already possesses some machine tool knowledge.

I consider this book to be very sound and would recommend it to students especially and to jig and tool designers and planners generally, but in the latter case I should imagine there will be enough live examples to work out without having to resort to those in this volume. R.E.M.

651.7 REPORTS: FORMS

"Design and Control of Business Forms" by Frank M. Knox. *New York, McGraw-Hill Book Comp.*, 1952. 219 *pages. Illustrated. Diagrams.* $6.50. (NOMA Series in Office Management.)

This is a comprehensive book, covering the field of business forms from many angles—from quality of paper to psychological and statistical problems.

The author estimates that the average company spends $8 to $10 in clerical expenditure for each $1 spent on forms. Therefore eight to ten times more attention should be given to the design of forms from the point of view of clerical expense, than that of printing or production costs.

Mr. Knox sets up five requirements for a good form design:

1. it must create a *favourable mental attitude* on the part of the operator towards the job;
2. it must afford the easiest possible method of *entering the data* on the form;
3. it must afford the easiest possible method of *using the data* after they have been entered on the form;
4. it must help to reduce the *tendency to error* in entering or using the data;
5. it must make for *paper and printing economy* within the limits set by efficient clerical use.

In the light of these requirements he examines various aspects of designing and controlling the forms. Bearing in mind the losses in efficiency caused by ill-designed forms, he advocates strict control on the managerial level, simplification and reduction of unnecessary variety. Many (illustrated) examples show strikingly the difference between "home-made" forms and their expert-designed counterparts.

On the whole, this book should be recommended to every head of clerical departments, especially in larger firms, where clerical expenditure runs into considerable amounts.

Although it does not in my opinion put big enough emphasis on methods of simplfying and "streamlining" office methods in operating the forms, Mr. Knox's book is a valuable work, throwing proper light on one of many complex problems of office organisation. E.G.B.

621.86 MATERIALS HANDLING

"Materials Handling" by John R. Immer. *New York, McGraw-Hill*, 1953. 591 *pages, illustrated, diagrams.* £2. 17. 6d.

This book is probably one of the most comprehensive yet published on this subject. The author has set out to cover a very wide field, and to do so he has had to leave out much detail that would have increased the value of the book. He has quoted widely from other works and other authorities, but as he gives full acknowledgments in every case the reader can refer to the original where he wishes to do so.

Like many other works on this subject, the book opens on a historical note and describes some of the very earliest examples of mechanical handling equipment. There follows a chapter on principles which completes Part I.

Part II deals with motion and time study and gives useful information to those seeking the basic knowledge of the subject that is necessary to anyone making a study of materials handling. Again, the amount of detail is not great, but the reader is referred to other books on the subject, mostly published in America.

Materials handling equipment is dealt with in Part III and as all the various types of equipment from sack barrows to aerial ropeways are described in less than a hundred pages, it is felt that the book would have been of greater value to people in industry if more space had been devoted to this aspect of the subject. In most cases only the briefest information is given.

The section on packaging is of limited interest only, but some details are given of research work being carried out in this country and in the United States.

Part V deals with analysis and includes surveys and two chapters on cost accounting systems and the determination of handling costs. The various aspects of these subjects are dealt with in a very comprehensive manner, but the approach is more academic than practical. There is a chapter on how to sell better handling methods, but it must be remembered that psychological methods, which might be very successful in the United States, might not be so well received in this country.

The next section covers organisation, production control, operator training, integration of equipment, maintenance and safety. All these subjects are dealt with very thoroughly, but all from the point of view of large organisations which are typical of American industry, but which are the exception rather than the rule in this country.

The final section is devoted to special handling problems and covers a very wide field. Numerous examples are given of machine operations, warehousing activities and assembly methods. There is a very interesting chapter on air cargo handling in the United States and many examples are given of the American approach to what will obviously be an ever-increasing problem in the future. The chapter on railroad and truck handling is of more interest in the United States than in this country owing to the different conditions and the different dimensions of rolling stock, but in the chapter on ship and barge handling the author describes what is being done in the American seaports and on the Great Lakes to find an answer to what is, perhaps, the greatest material handling problem in the world today.

There is an Appendix giving selected sources of information, a bibliography of magazine references and a list of visual aids. The book is copiously illustrated and well indexed, and in general will probably be of more use to the student as a textbook than to people in industry with specific problems to solve. F.T.D.

"Materials Handling Manual" ed. by Carl C. Harrington. *New York, Conover-Mast Publications Inc.*, 1952. 434 *pages, illustrations, diagrams.* £2. 10s.

This book is generally descriptive rather than highly technical and it is well indexed and illustrated. It will be of more value to those looking for elementary descriptions of various types of equipment rather than to those with definite problems to solve.

More space is given to auxiliary equipment than is usual in books of this nature, and it is felt that more space might have been given to conveyors and less to things like hooks, slings, ropes and jacks.

At the beginning of the book there are some good descriptions and illustrations of a large number of trucks of various types, followed by a chapter on wheels and castors. There follows a chapter on portable lifts and elevators which is quite comprehensive, but a good deal of the equipment described and illustrated has been largely superseded by the fork lift truck.

The chapter on dock levellers is interesting as there has not been much information published in this country on this subject up to the present, but the one on unit loads does not add much to what is already generally known. There are some interesting descriptions of self-propelled cranes, but it is doubtful whether some of the types described and illustrated are available in this country.

The book then goes on to some good descriptions of overhead monorail runways, hoists and cranes, and then diverges from its general theme by devoting much space to detailed descriptions of grips, tongs and slings of wire rope and fibre rope. It is felt that these descriptions could have been better placed in an appendix as they deal with details rather than with principles.

The chapters dealing with flat and troughed belt conveyors give more technical details than most of the others, but the usual practice is now rather to rely on the belt manufacturer to advise on the size and composition of the belt for specific applications, as the manufacturer of conveyor belts tends to become more and more a specialised business.

Gravity conveyors and chutes are described and illustrated fully but without much technical detail, and there is a brief but interesting description of an automatic pallet loader.

Overhead chain conveyors do not seem to have been given the space they deserve in a book of this nature, and only the briefest description is given. No mention is made of automatic loading and unloading devices nor of the various types of preselector gear which have been developed in recent years. The twin-rail overhead chain conveyor is not mentioned at all.

The chapter dealing with flight, drag, apron and slat conveyors is very brief indeed considering the number of different types that come under these headings. Bucket elevators and pneumatic conveyors are described at greater length but without much technical detail.

There is a chapter on miscellaneous conveyors and one on freight elevators, and the remainder of the book is devoted to auxiliary equipment such as racks and bins, industrial scales, and jacks and rams. F.T.D.

ABSTRACTS

621.365 ELECTRIC HEATING

"Electric Resistance Heating." (Electricity and Productivity Series No. 5.) *British Electrical Development Association, London. London, the Association*, (1953). 182 *pages. Illustrated. Diagrams.*

This book consists of thirteen chapters on the various broad aspects of electric resistance heating. This name covers virtually all electric heating apart from the induction and dielectric types which are covered in a separate volume in this series. Each chapter is further broken down into the variants possible on each aspect, together with a photograph of a typical commercial example. These photographs, generally speaking, cover the equipment in actual production use and should be useful to Production Engineers.

The main types of ovens and furnaces covered include electric salt baths, infra-red and convection ovens, electric resistance furnaces and electric steam boilers. Other chapters cover soft metal melting, liquid heating, platten, press and roll heating and various miscellaneous applications of electric heating.

621.791 WELDING

"Welding of Austenitic Corrosion and Heat-Resisting Steels." *British Welding Research Association, London. London, the Association,* 1953. 207 *pages. Illustrated. Diagrams.* £1 17s. 6d.

The book is written by a committee of experts representing all sections of industry.

After a brief review of welding processes and metallurgical factors involved in welding these materials, there is a description of the welding equipments, its operation, recommended joint preparations and special techniques for each process.

Another chapter deals with the cutting methods used for fabricating parts. Post-welding treatment such as finishing (grinding and polishing) heat treatment, inspection and testing methods are examined and procedures recommended.

The final chapters consider the problems of welding clad and special heat resisting varieties. Appendices list the proprietary types and the standard specification for austenitic corrosion and heat resisting steels. There is an extensive bibliography.

OTHER ADDITIONS

658.54 TIME AND MOTION STUDY

Dipple, S. Bloye. **"Time Study in Light Industry."** *Manchester, Emmott & Co. Ltd.,* 1946. 65 *pages. Charts.* 2/6. (Mechanical World Monographs.)

Imperial Chemical Industries Ltd.—Central Labour Department, London. **"Implications of Work Study."** *London, The Department,* 1952. 20 *pages.*

Cotton Board — **"Work Study Conference, St. Annes-on-Sea, 1952."** Papers. *Manchester, the Board,* 1952. 57 *pages. Charts.* 3/-.

658.5 PRODUCTION PLANNING AND CONTROL

Blank, H. E., *ed.* **"How to Cut Production Costs: A Guide to Better Methods and Techniques."** *New York, Funk & Wagnalls Co., in association with Modern Industry Magazine,* 1949. 384 *pages.* (Modern Industry Books.)

British Specialist Team on Production Planning and Control. **"Production Control: Report of a Visit to the U.S.A. in 1951."** *London, British Productivity Council,* 1953. 130 *pages. Illustrated. Charts.* 5/-. (Productivity Report.)

Huckle, A. H. **"Planning The Small Factory."** *London, Mitre Press,* [n.d.] 133 *pages. Diagrams.* 15/-.

669 METALS; METALLURGY

Great Britain—Ministry of Supply—Metals Economy Advisory Committee. **"Report."** *London, H.M.S.O.,* 1952. 17 *pages.* 9d.

Aitchison, Leslie. **"Introduction to Industrial Metallurgy."** *London, Macdonald & Evans,* 1949. 456 *pages. Diagrams.*

378.962 TECHNICAL COLLEGES

Zürich—Eidgenössische Technische Hochschule. **"Program und Stundenplan für das Winter-semester, 1953/54."** *Zürich, The School,* 1953. 160 *pages.*

378.996 TECHNICAL EDUCATION

British Engineering Training Mission to Latin America. **"Training in Britain of Engineers from Latin America: Report of the . . . Mission."** *London, Federation of British Industries,* 1952. 64 *pages.* 7/6.

744 TECHNICAL DRAWING

French, Thomas E., *and* Svensen, Carl L. **"Mechanical Drawing: A Text with Problem Layouts."** *5th edition. Revised and enlarged. New York, McGraw-Hill,* 1948. 437 *pages. Illustrated. Diagrams.*

331.15 INDUSTRIAL RELATIONS

Riegel, John W. **"Management, Labour, and Technological Change."** *Ann Arbor, University of Michigan Press,* 1942. 187 *pages.* (University of Michigan—Reports of the Bureau of Industrial Relations, No. 3.)

658. INDUSTRIAL ORGANISATION; MANAGEMENT

Barish, Norman N. **"Systems Analysis for Effective Administration."** *New York, Funk & Wagnalls Co. in association with Modern Industry Magazine,* 1951. 315 *pages. Illustrated. Diagrams.* $5.00. (Modern Industry Books.)

658.14 FINANCING; CAPITALISATION

Andrews, P. W. S., *and* Brunner, Elizabeth. **"Capital Development in Steel": A Study of the United Steel Companies Ltd.** *Oxford, Blackwell,* 1951. 374 *pages. Illustrated. Diagrams.*

331.2 WAGES; PAY

Peterson, Robert L. **"Work Incentives for Your Personnel."** *University of Illinois—Business Management Service,* 1952. 20 *pages. Illustrated.* (University of Illinois Bulletin. Volume 49, No. 46, February, 1952. Business Management Service Bulletin No. 503.)

331.215 JOB EVALUATION

Smyth, Richard C., *and* Murphy, Matthew J. **"Job Evaluation and Employee Rating."** *New York, McGraw-Hill,* 1946. 255 *pages.* (McGraw-Hill Industrial Organisation and Management Series.)

331.5 SPECIAL TYPES OF WORKERS

Great Britain—Ministry of Labour and National Service. **"Age and Employment"; prepared by the Ministry of Labour . . . and the Central Office of Information.** *London, the Ministry,* 1953. 12 *pages. Diagrams.*

331.84 USE OF LEISURE; RECREATION

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338.9 PRODUCTIVITY

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338.91 INDUSTRIAL PRODUCTION

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621.92 GRINDING ; POLISHING

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669.71 ALUMINIUM

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681.2 INSTRUMENT MAKING

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Imperial Typewriter Company Ltd., Leicester. **" Making Imperial Typewriters."** *Leicester, The Company,* [1953.] 90 *pages. Illustrated.*

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914.2 GREAT BRITAIN—DIRECTORIES

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538 MAGNETISM ; ELECTROMAGNETISM

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Abbott, A. **" Wages Procedures."** *London, Office Management Association,* 1949. 43 *pages. Illustrated. Diagrams.* 5/-.

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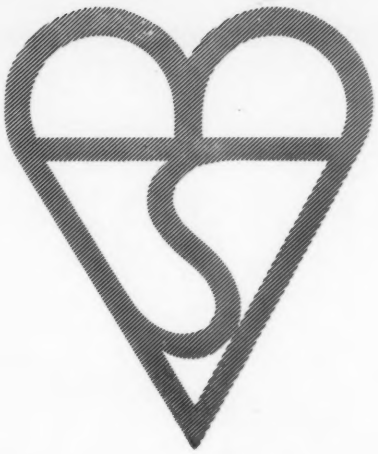

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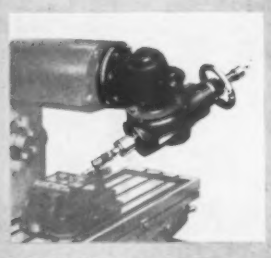

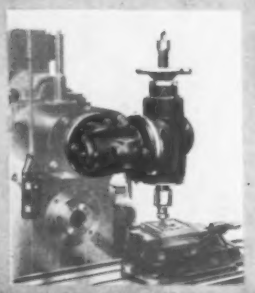

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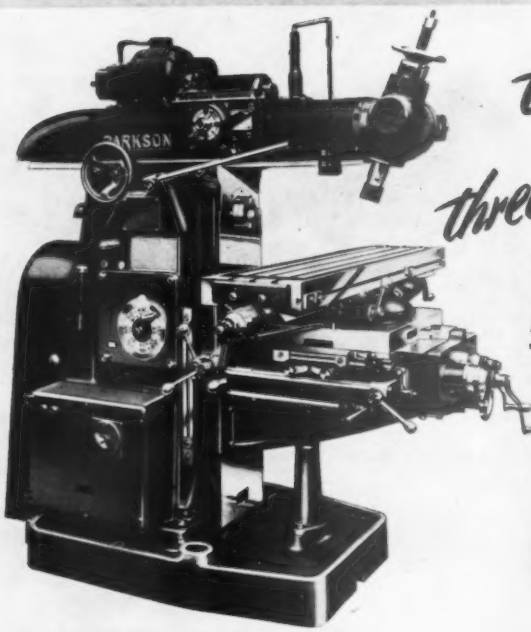

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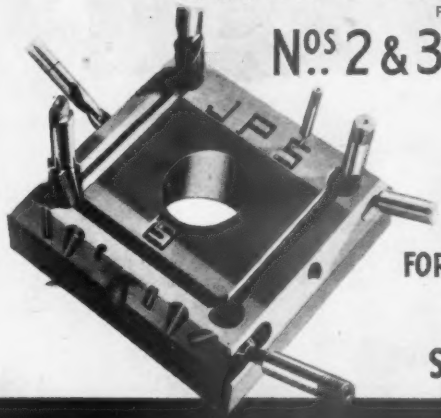

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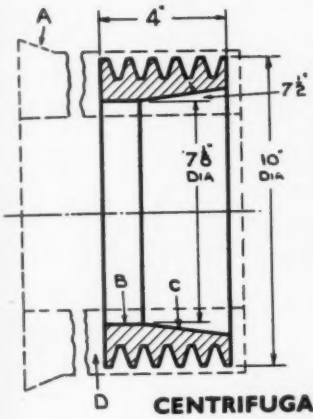

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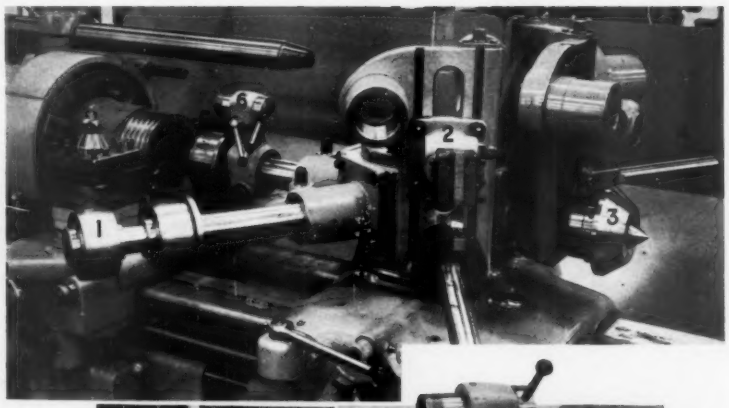
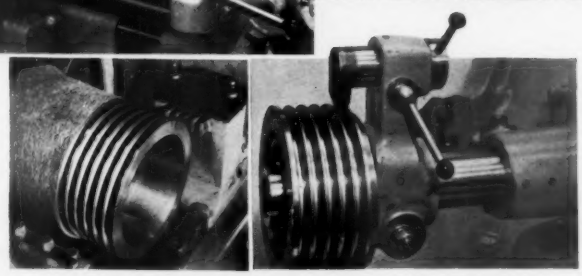
DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per Inch
	Hex. Turret	Cross-slide			
Chuck (using Loader) at A	1	—	—	—	—
Rough Face End	—	S.T.1	125	335	·84
Rough Bore B and C and Turn 10" dia.	2	—	125	325	84
Support and Rough Vee Grooves	3	Rear	40/24	110/60	246
Support and Finish Vee Grooves	3	S.T.2	75	200	Hand
Finish Bore B and finish Turn 10" dia.	4	—	125	325	84
Finish Taper Bore C	5	Rear	125	260	84
Chamfer Vee Grooves	—	S.T.3	125	325	Hand
Support (unloader) and Part-off D	6	S.T.4	59/75	150/200	176

CENTRIFUGALLY CAST IRON Floor to Floor Time: 28 minutes..





Capacity:

4¼ in. dia. hole through spindle.

23 in. dia. swing over stainless steel bed covers.

Spindle:

Mounted in ball and roller bearings.

Powerful metal-to-metal cone clutches transmit power through ground gears.

OUR COMPLETE RANGE INCLUDES CAPSTAN AND TURRET LATHES WITH CAPACITIES UP TO 35 in. SWING OVER BED AND 8½ in. DIA. HOLE THROUGH SPINDLE.

Full details on request

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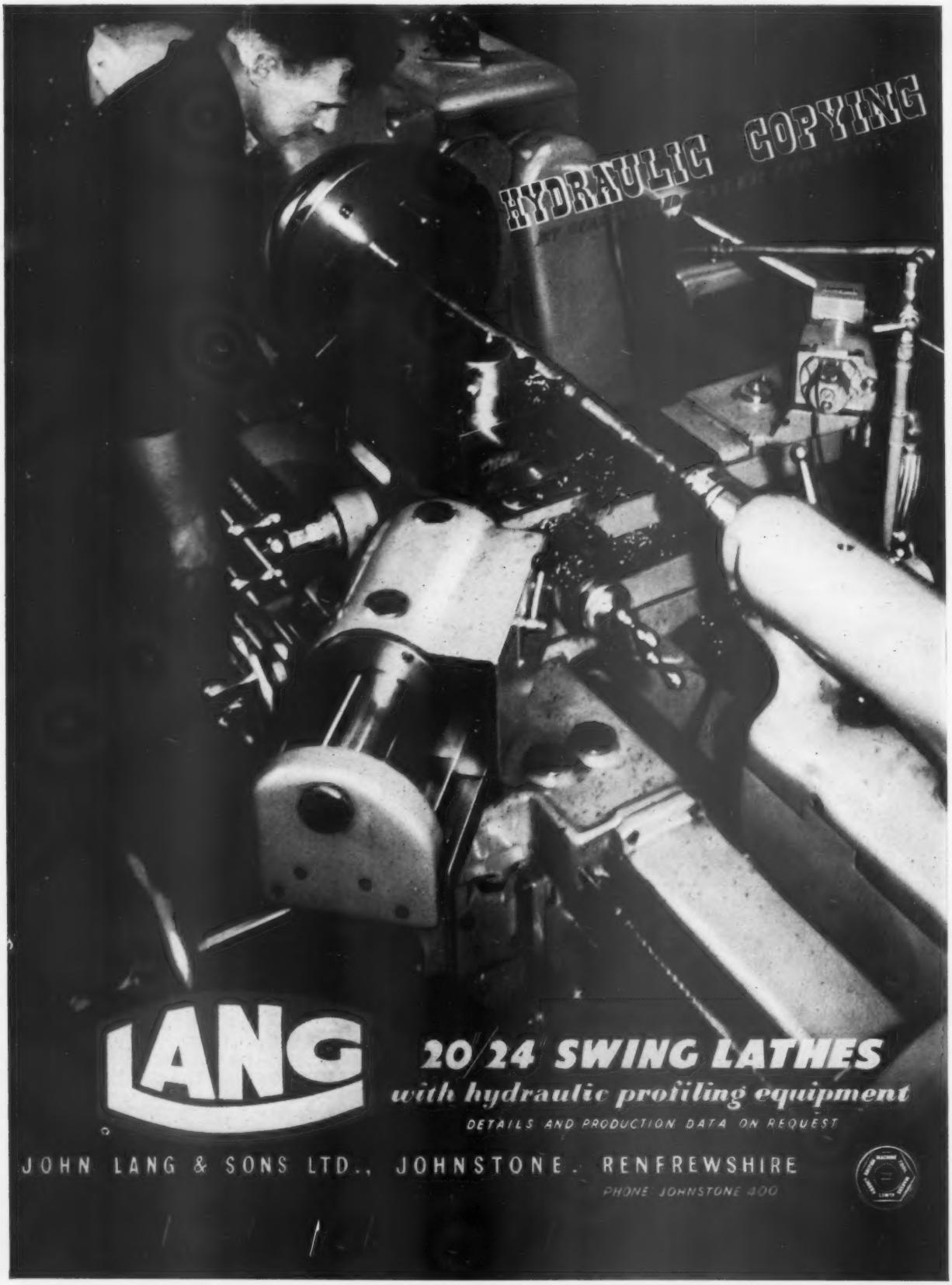
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DETAILS AND PRODUCTION DATA ON REQUEST
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Change gears are conveniently located at the side of the machine—another MAXICUT time-saving feature.

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Independent portable self-contained hydraulic units to supply pressure from **250 to 8000 lbs/sq. in.** at any desired point .....

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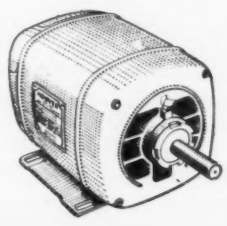

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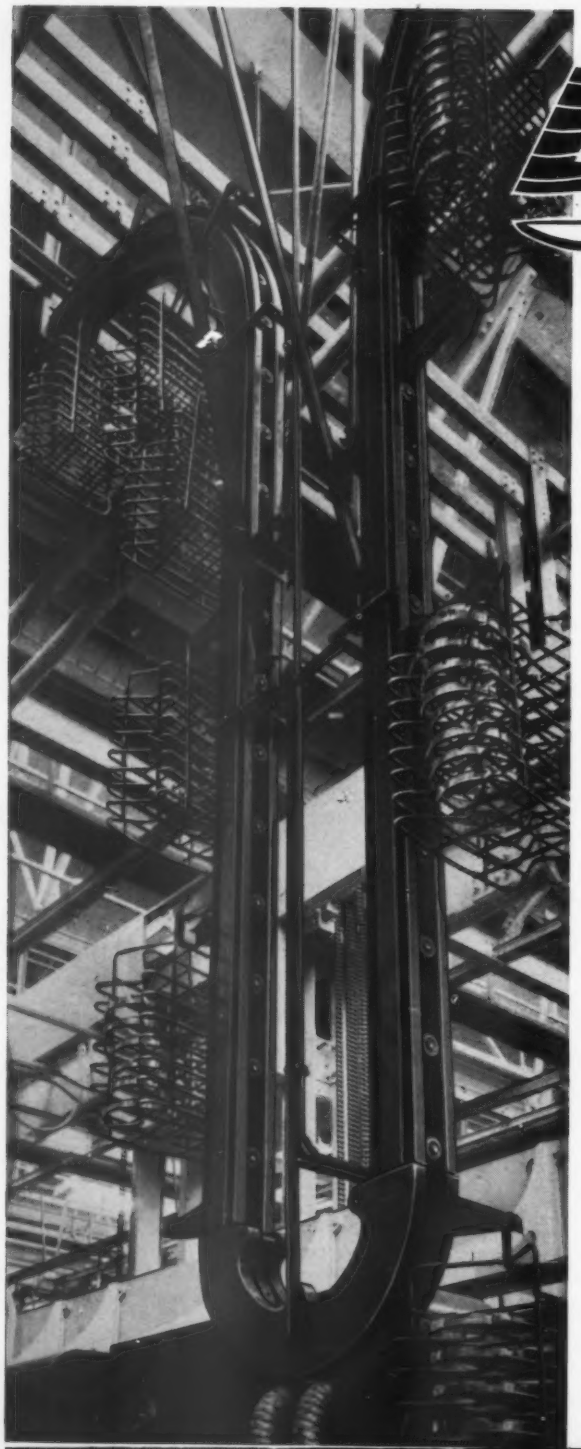

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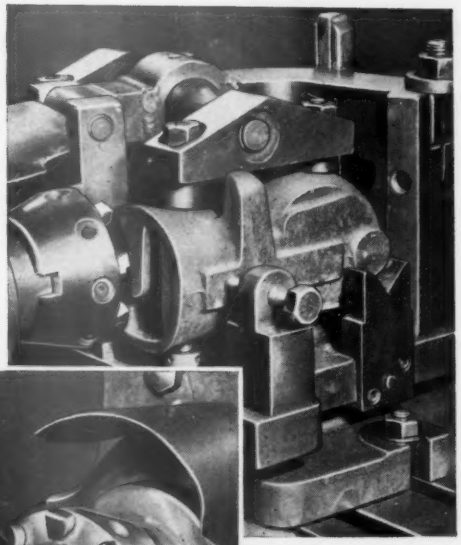

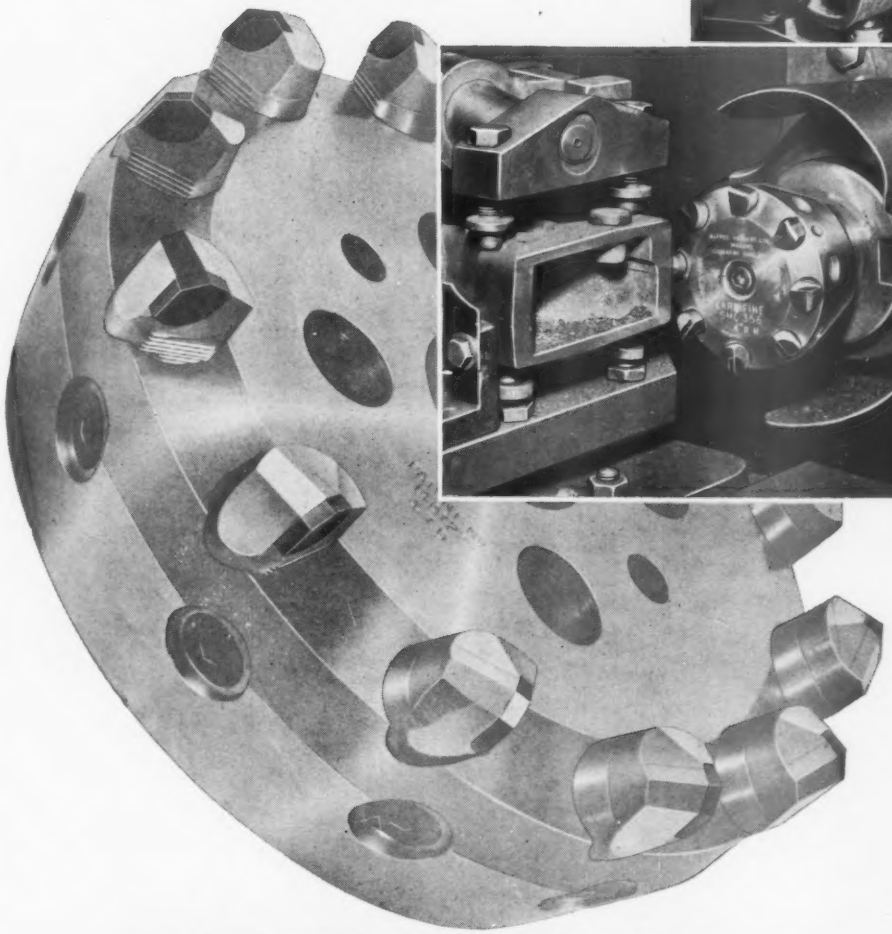

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Eleven sizes—3" to 16" dia.
CARBIFINE. For light cuts on cast-iron and non-ferrous materials. High degree of surface finish on interrupted surfaces.
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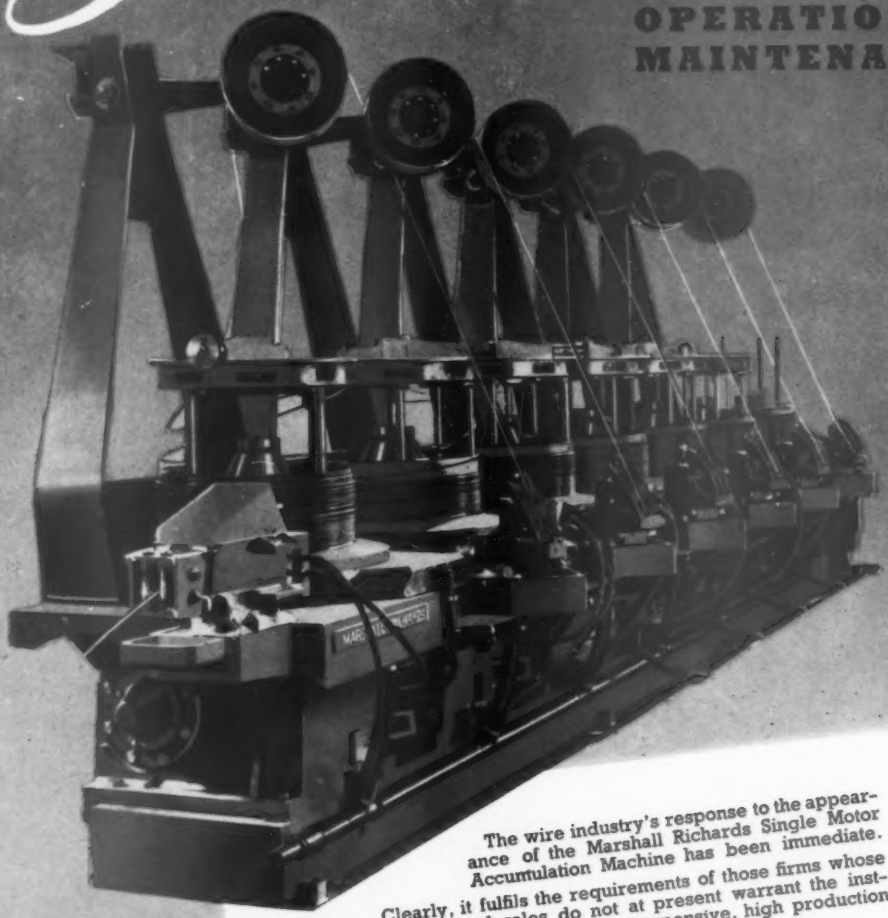

The wire industry's response to the appearance of the Marshall Richards Single Motor Accumulation Machine has been immediate.

Clearly, it fulfils the requirements of those firms whose output, method and sales do not at present warrant the installation of the more modern, more expensive, high production machines we also make.

Standard models are available on reasonable deliveries; air cooling is fitted to all high carbon machines; drawing speeds are high – and Marshall Richards first class QUALITY engineering is built into every one.

We invite you to send for our new catalogue of these Type SMA machines.

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A MEMBER OF THE MARSHALL ORGANISATION

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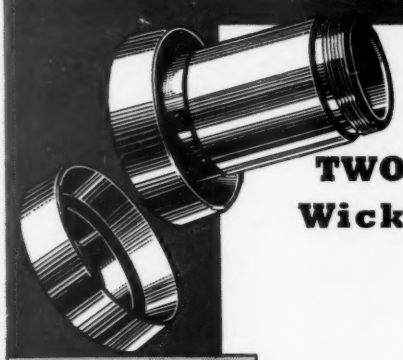
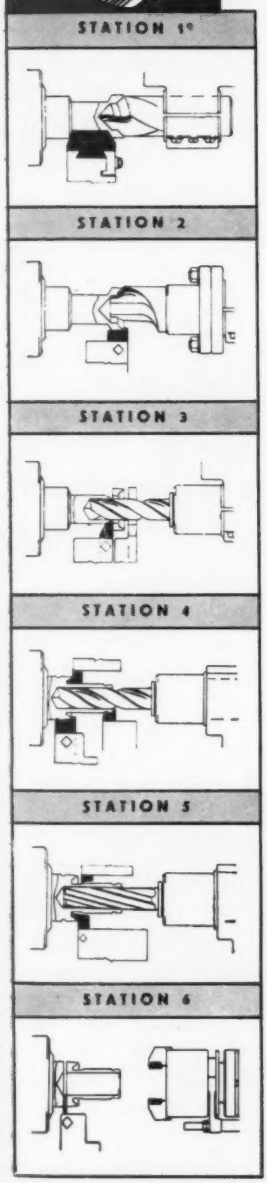


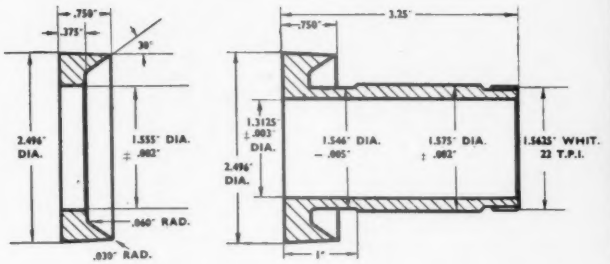
Another user gets an output bonus!

TWO PARTS produced together on the Wickman Multi-spindle Automatic

in 91 seconds

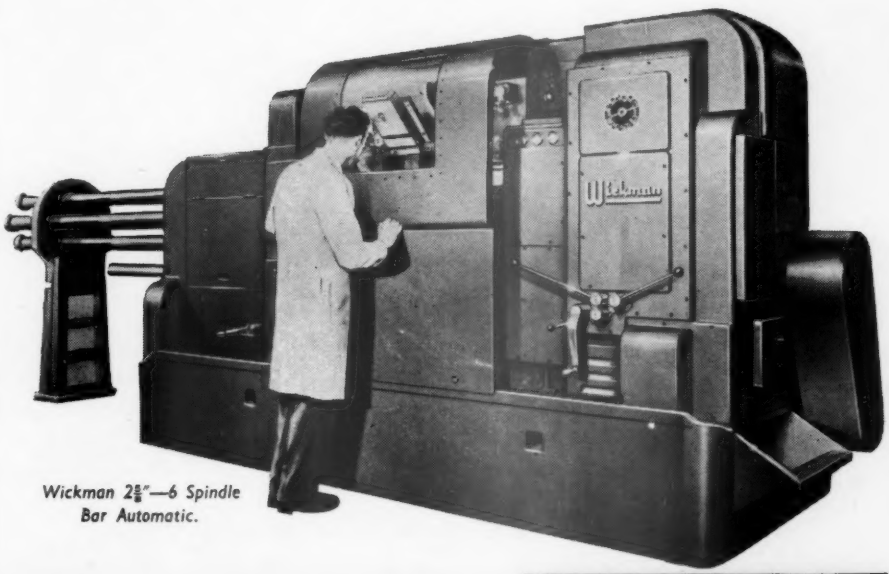


Commutator Hub and Clamping Ring (Mild Steel).



So often the production engineer thinks in terms of one part, and one machine to make it . . . and although it may be the exception rather than the rule to make two parts together on a Wickman Automatic, this example demonstrates the outlook of Wickman Engineers in planning for maximum machine utilisation, and the exceptional tooling opportunities offered by the range of Multi-spindle Automatics.

Whether you're looking for higher output, or putting new parts into production, it will pay you to let Wickman engineers investigate the possibilities of tooling up a Multi-spindle Automatic to meet your requirements. Remember, there are no expensive interchangeable cams to design and make; by means of the Wickman patent autosetting mechanism all tool feed strokes and bar feed can be set in a matter of minutes, and a wide range of standard attachments is available.



Wickman 2⅝"—6 Spindle Bar Automatic.

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Wickman

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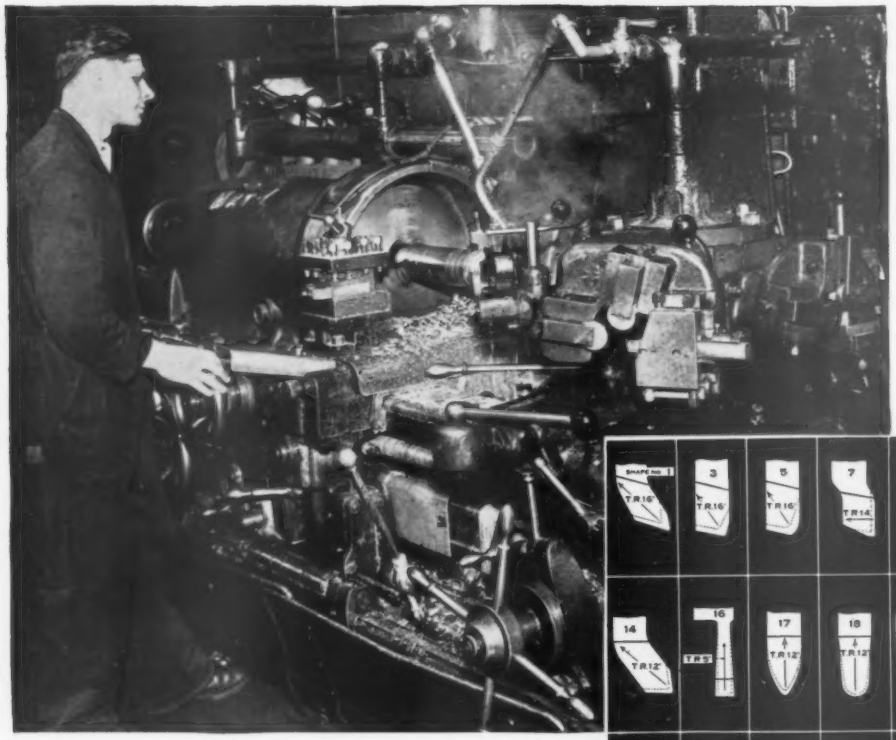

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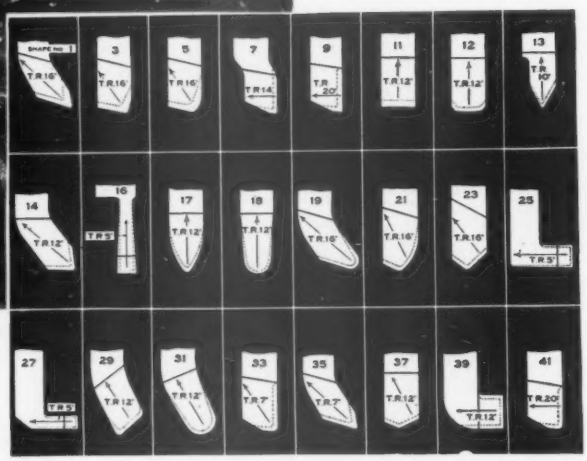

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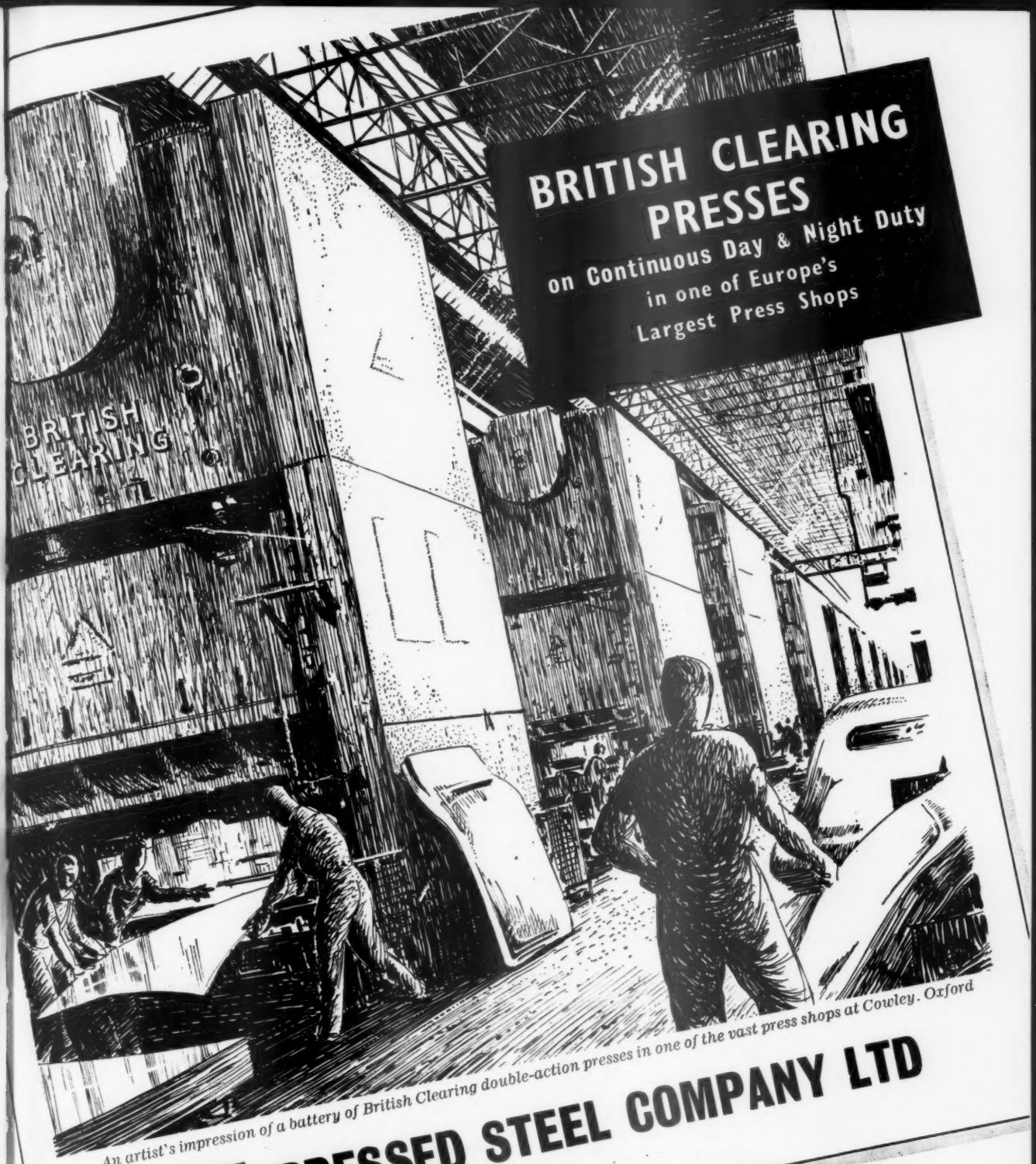

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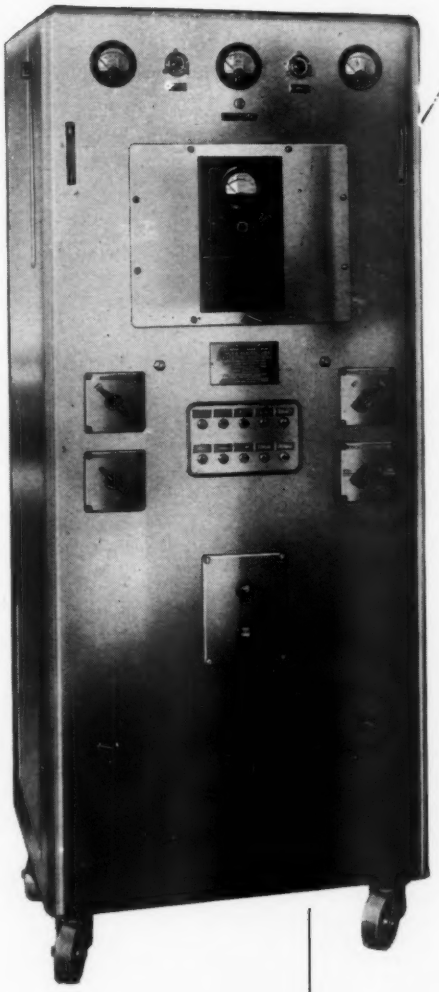

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they are always obtainable from Unbrako Distributors throughout the world.

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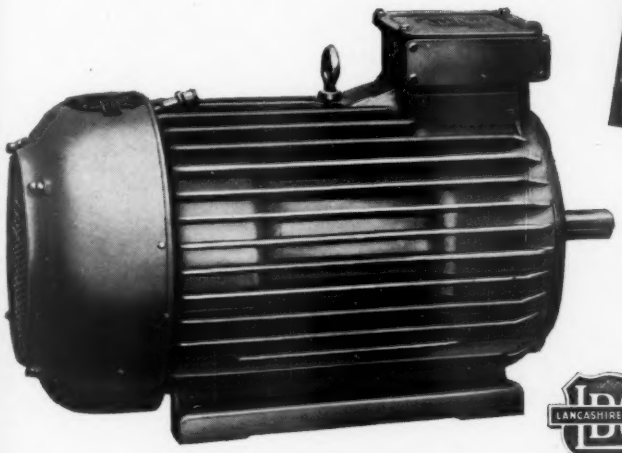

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Largest dia. of component (Brass) .. .275″
Largest dia. of component (Steel) .. .236″
Maximum length of component .. 2.952″
Spindle speeds .. .. 1980—6000 R.P.M.

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MODERN DESIGN · EASY SETTING PRECISION WITH EFFICIENCY...

Maximum gear dia. .. .. .. 2.480″
Maximum face width .. .. .. 1.575″
Maximum pitch module 8
8 cutter spindle speeds from 500—2500 R.P.M.

Precision Automatic Model G.12.

VERSATILE IN USE · SIMPLE IN SETTING · ELECTRICAL CONTROL

Largest dia. of component, round 12.7 m/m.
Maximum length of component 140 m/m
Working spindle speeds 1000—8000 R.P.M.

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Size of centres	No. 2 Morse Taper
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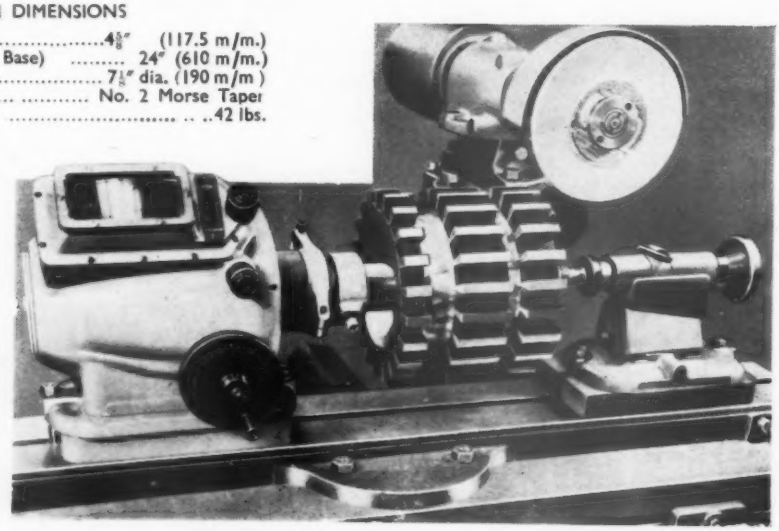

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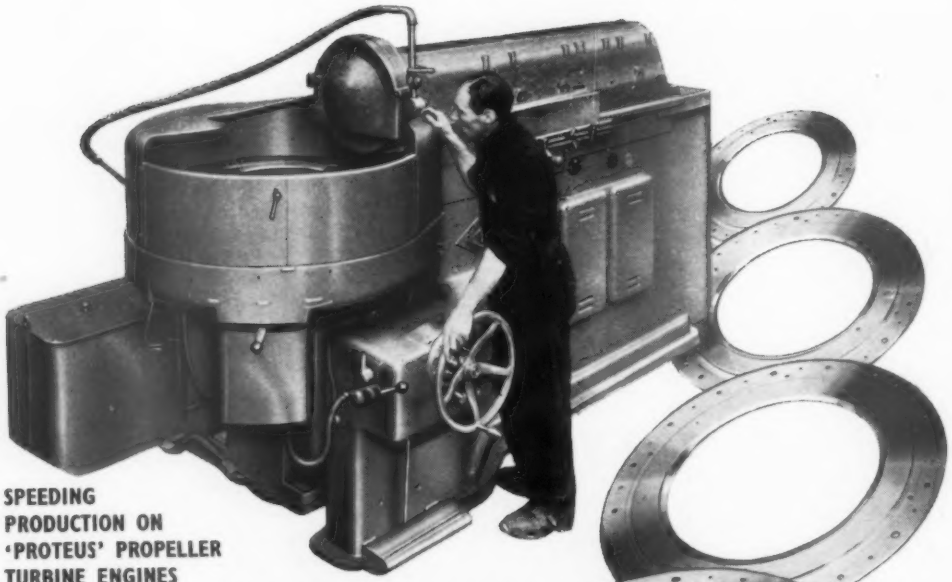

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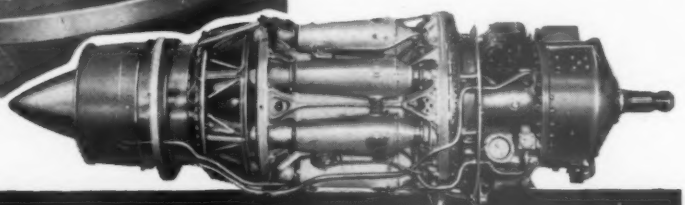

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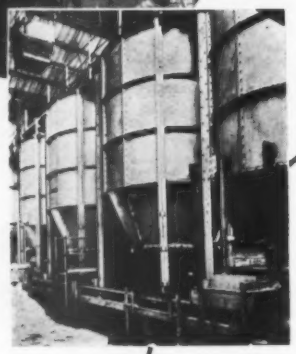

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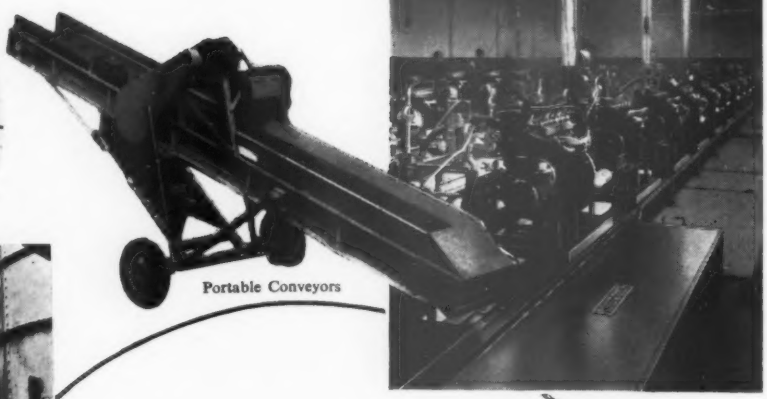

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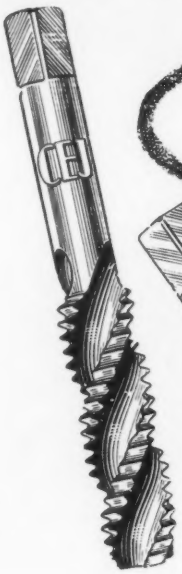

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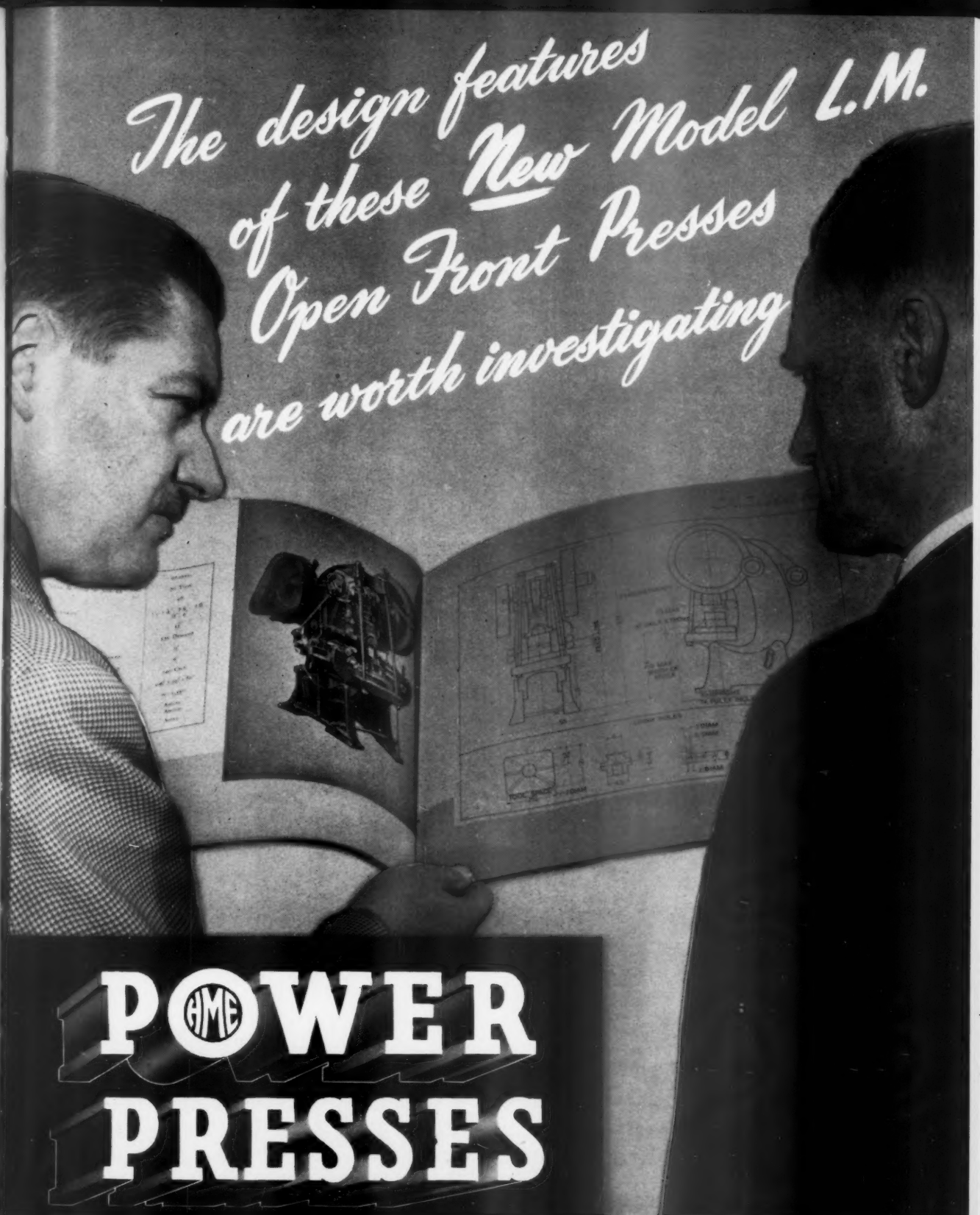

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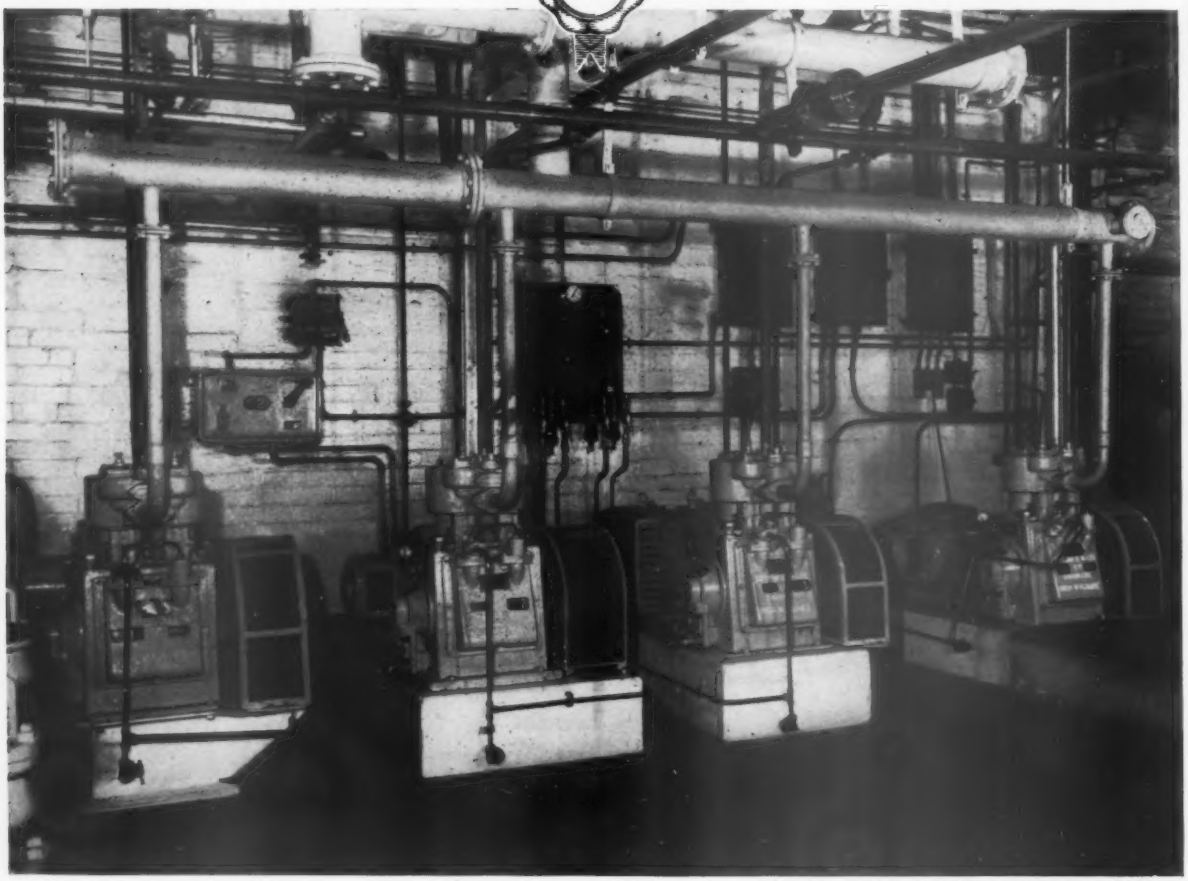

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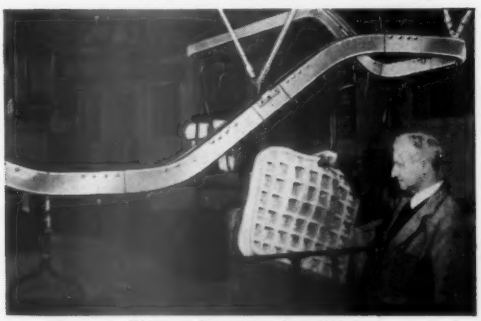

Picture of conveyor in action.

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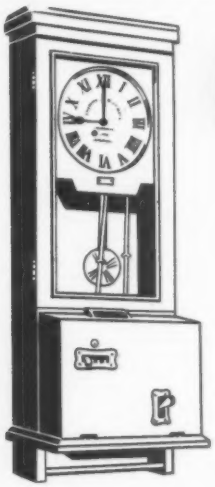

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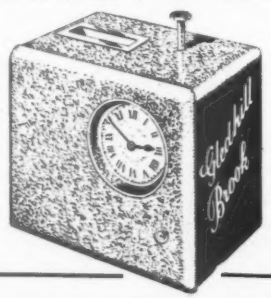

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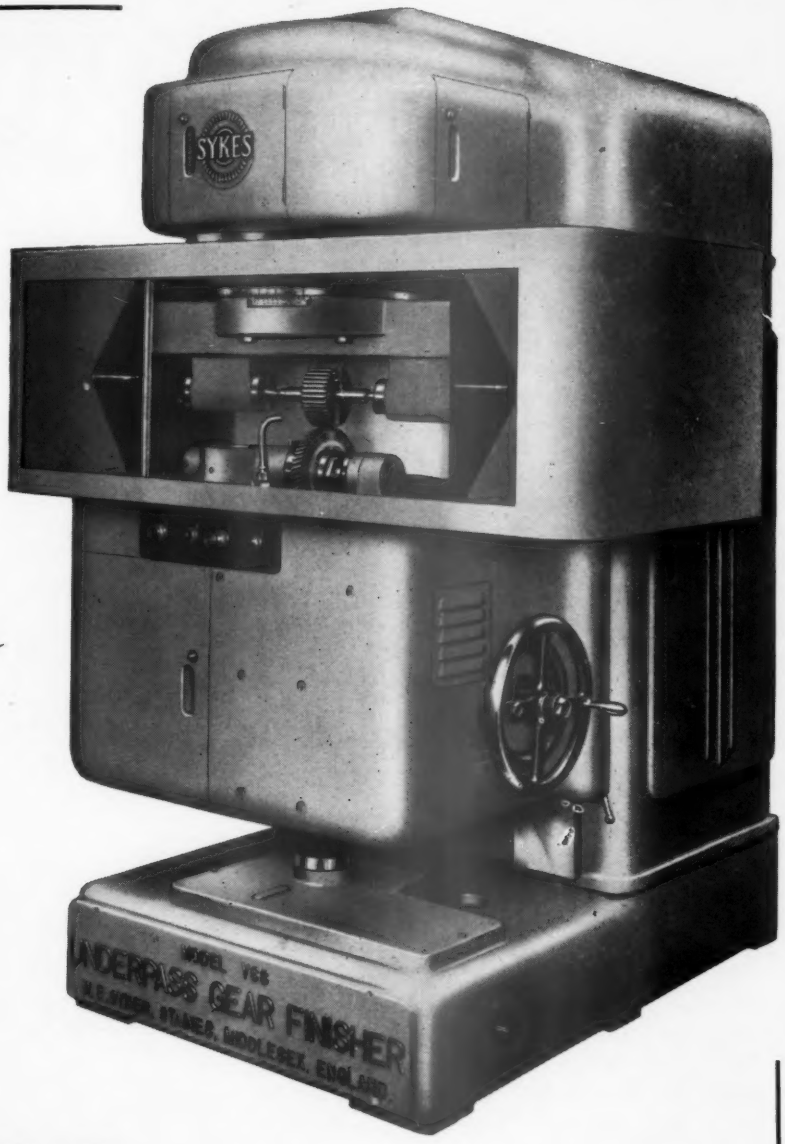

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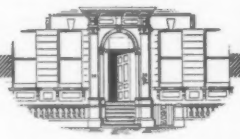

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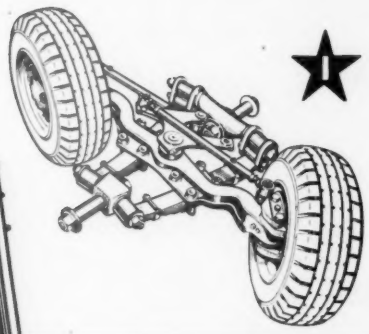

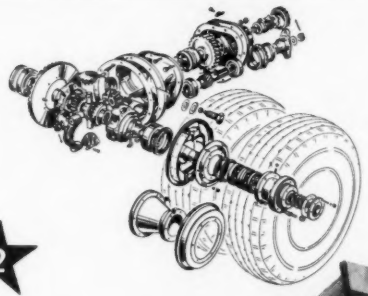

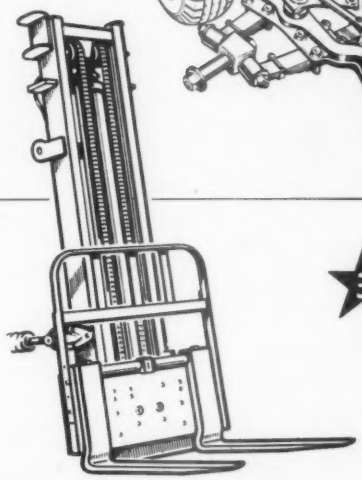

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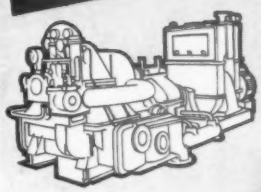

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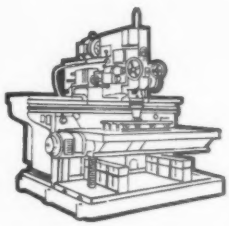

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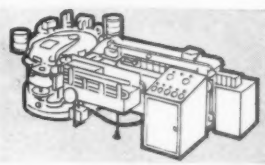

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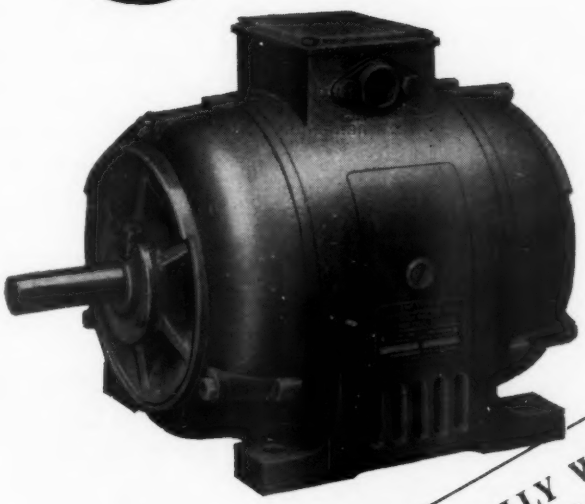

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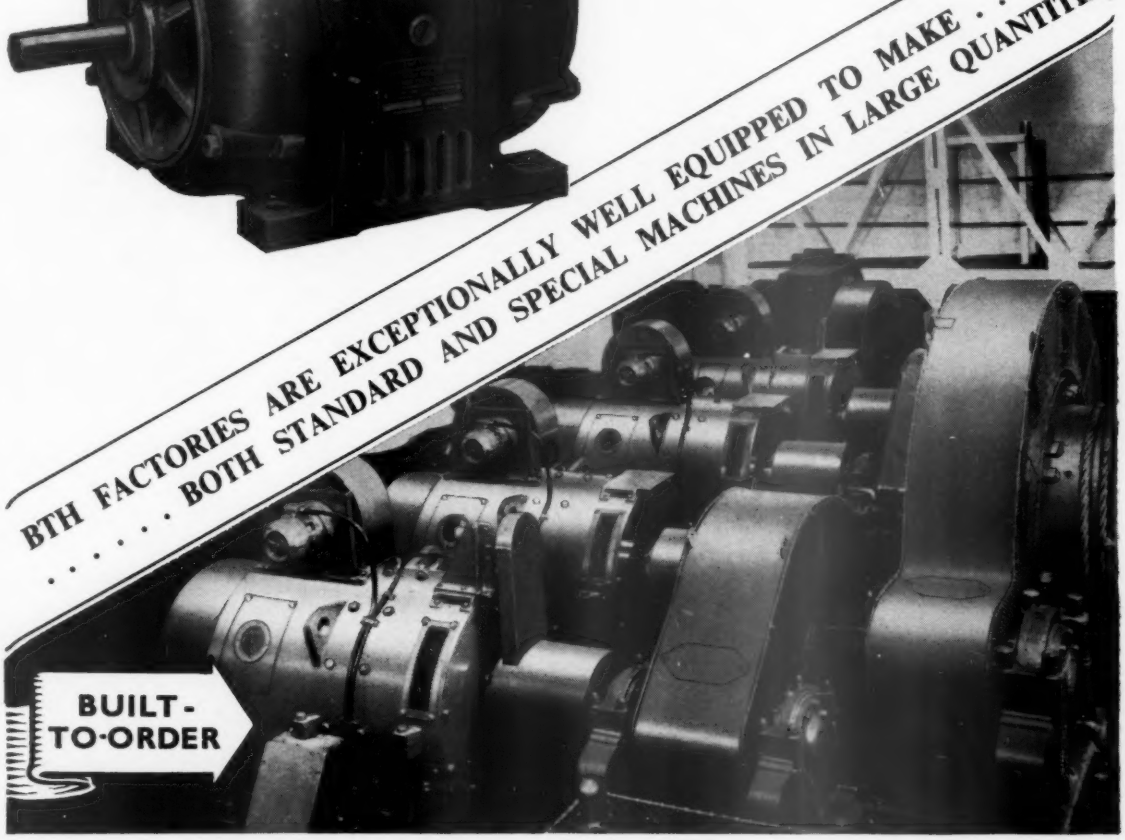

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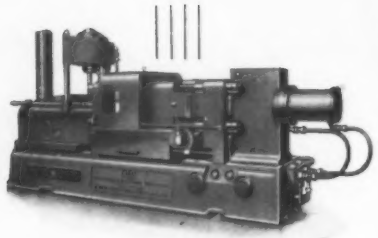

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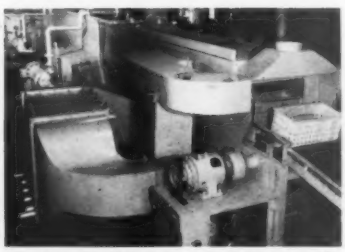
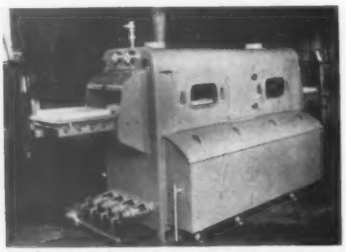
can be designed to meet your particular cleaning problems

This illustration shows a machine cleaning crank cases in the production line. It is equally capable of cleaning small parts in baskets.



A power driven conveyor system is employed with this cleaning machine for ball bearings.



Trays carrying the work are pushed through on a roller conveyor by hand in this cleaning installation.

Whilst offering a very wide variety of standard cleaning equipment, it is BRATBY policy, wherever possible to design the machine to meet the particular cleaning problem. Careful study of each individual problem ensures maximum efficiency and economy of the plant in operation. The illustrations show but a few of the specific types of Cleaning Machines designed by BRATBY for individual needs.

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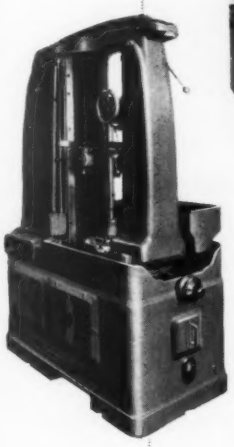

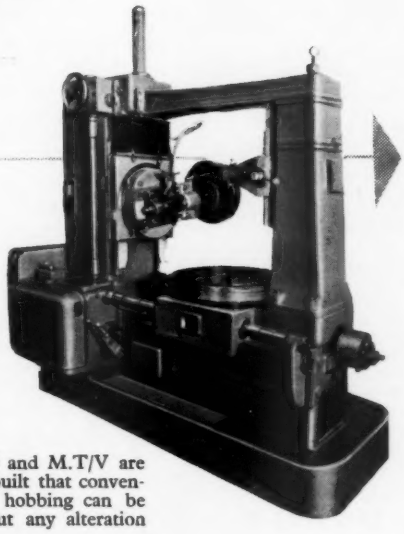

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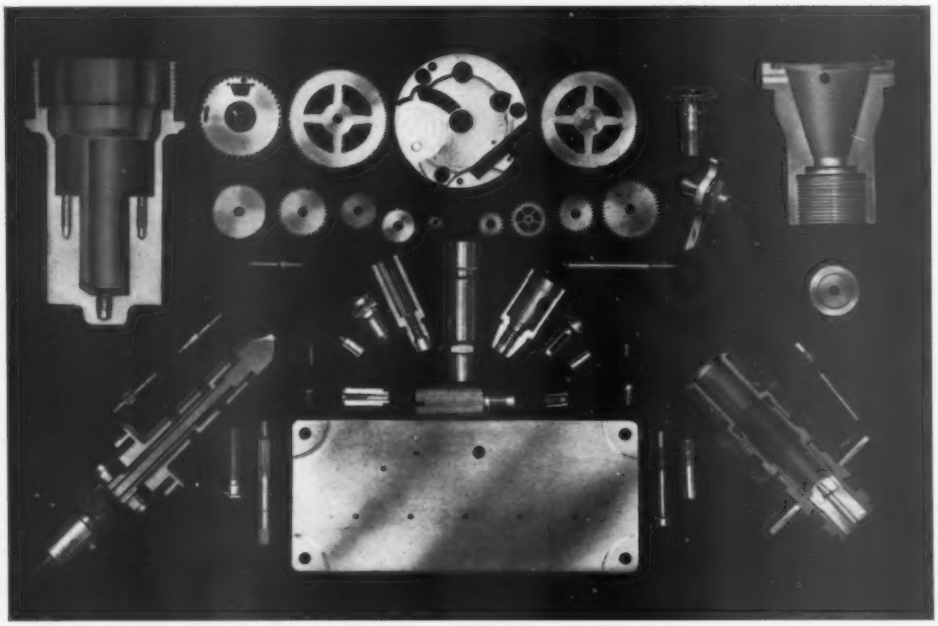

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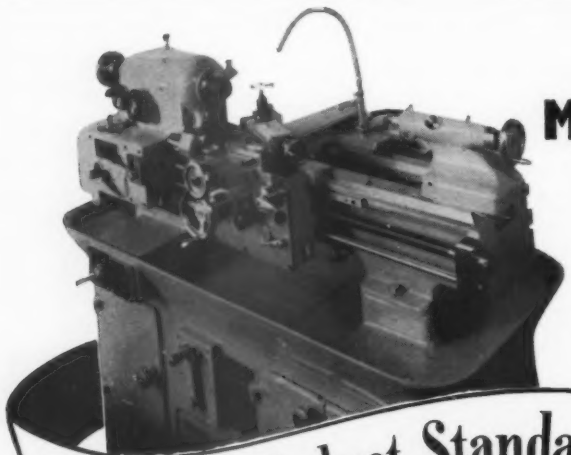

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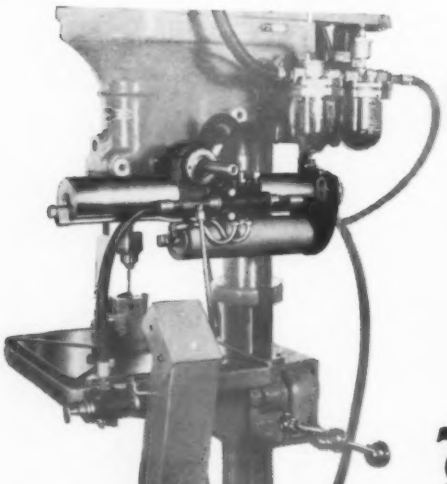

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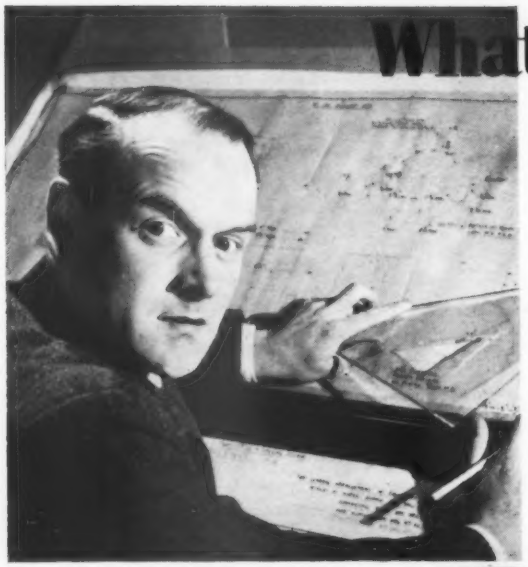

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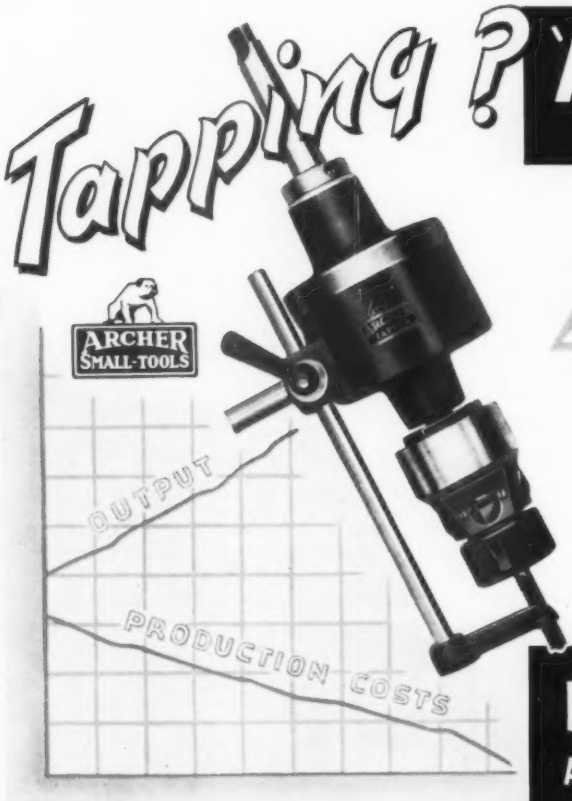

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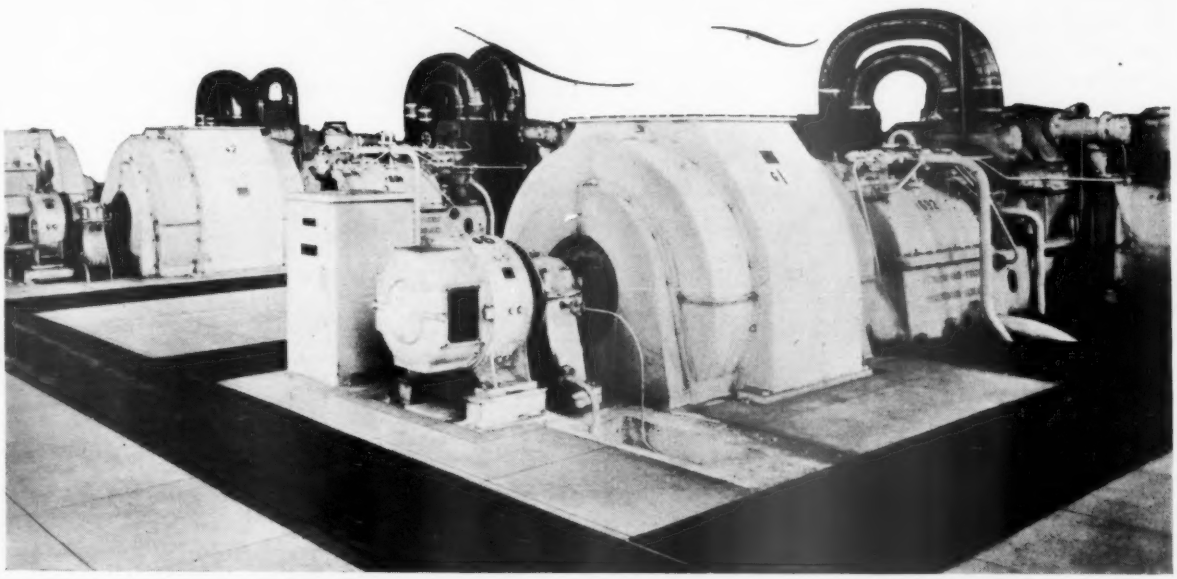

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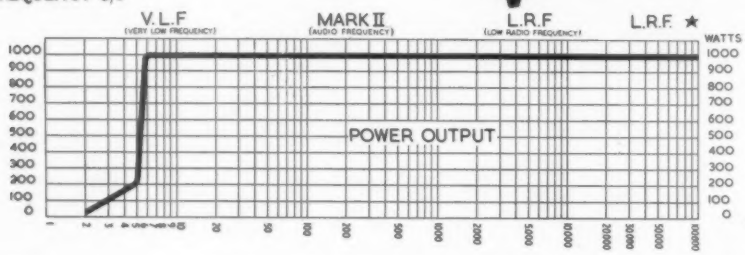

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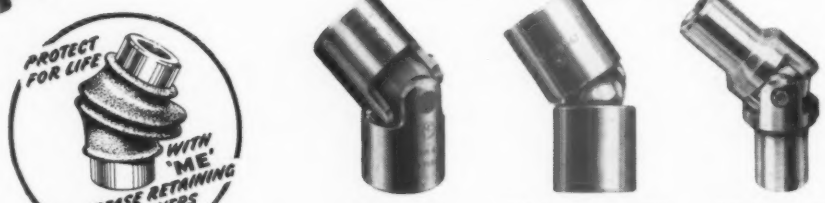

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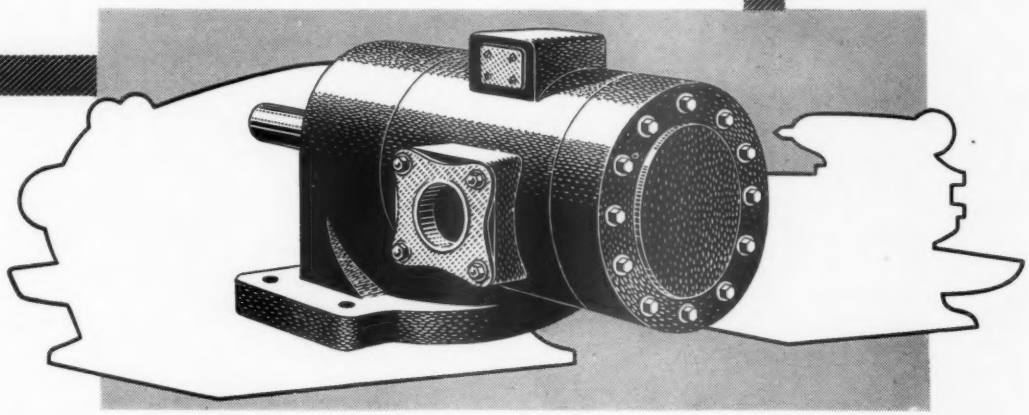

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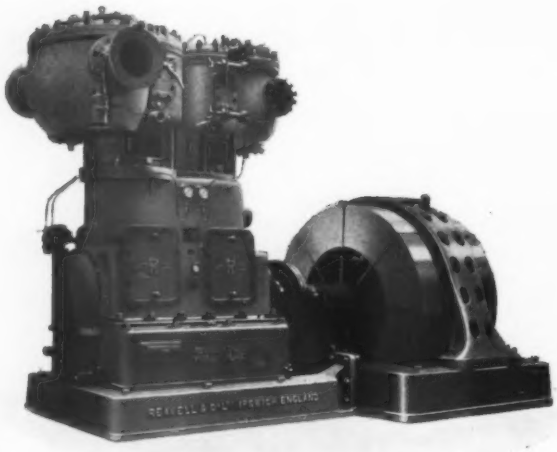

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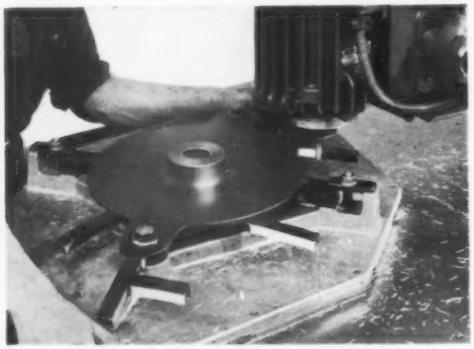

A typical profiling job on the Wadkin Heavy Duty Router L.U.

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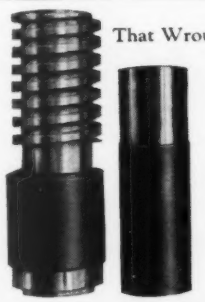

That Wrought Iron has outstanding machining properties is strikingly demonstrated by these typical test pieces. Its ductility is equally notable, while its essentially fibrous character gives it a toughness which enables it to stand up to severe vibrations, absorb varying stresses and recover from sudden shock.

Unrivalled in its ability to withstand shock and overstrain, Wrought Iron is renowned for its rust-resisting properties. Its natural susceptibility to welding is enhanced by slag inclusions; it is safer and more economical than mild steel for many long-term purposes — especially out-of-doors or under wet conditions.

Wrought Iron in strips and bars and in a variety of sections is produced at the Midland Iron Works for innumerable uses. A free copy of our Section Book will be sent on request, while our technical representative will be glad to advise you on any aspect of Wrought Iron usage.

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. . . you can safely use Wrought Iron for a host of purposes

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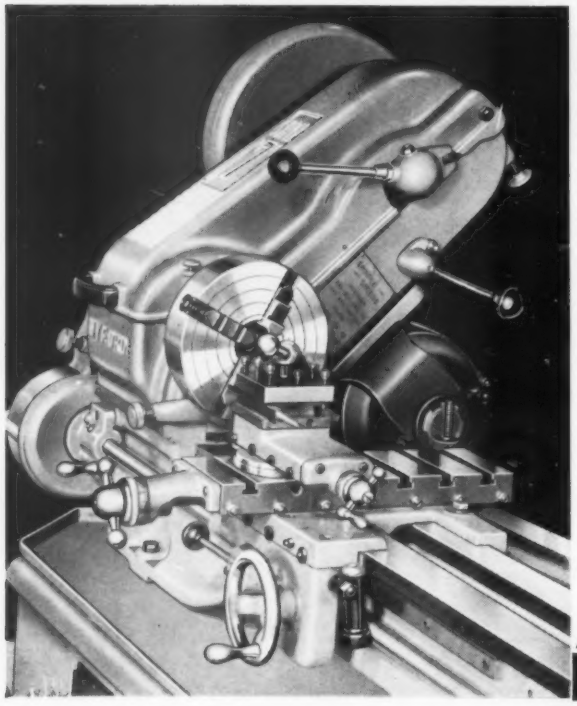

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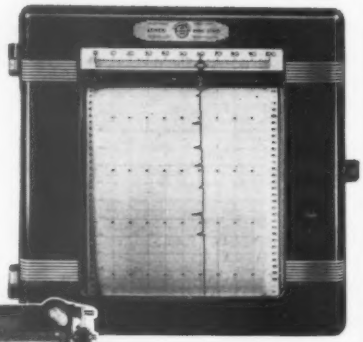

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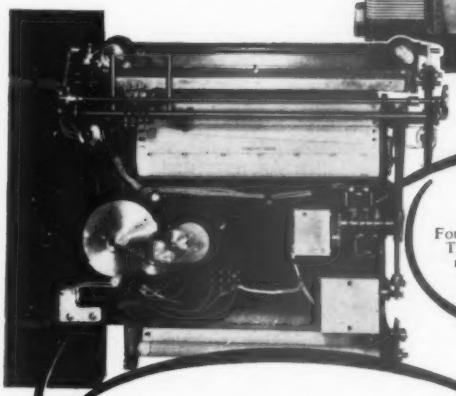

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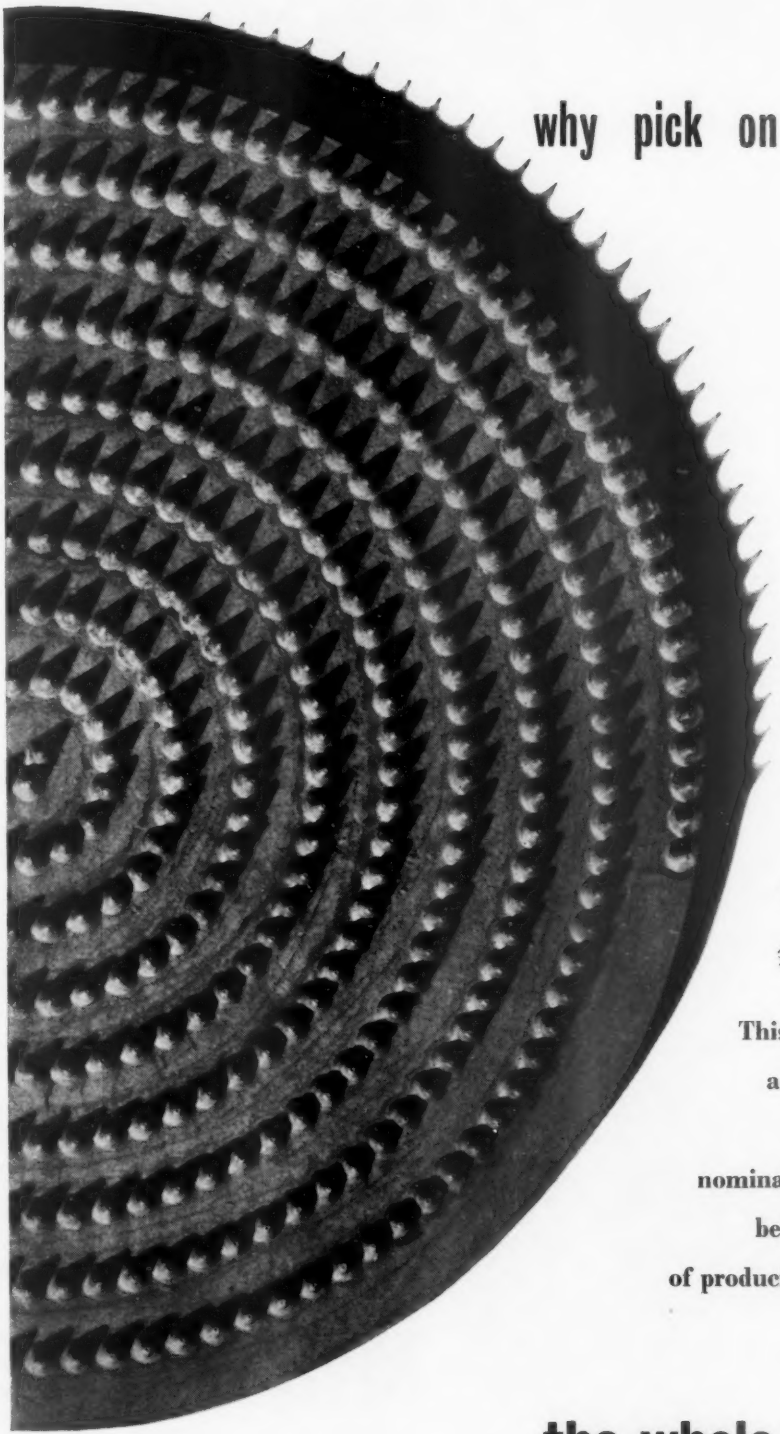

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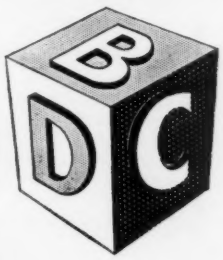

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This pressing illustrates simply, albeit effectiveiy, the principle that is applied in this process of manufacture. It is the end wall of a rail container. In its basic form the sheet of metal with which each end is formed would be insufficiently rigid, but certain contours are introduced by *pressing* and these impart to the sheet of metal the required degree of rigidity and strength. *The press used for this pressing is believed to be the largest of its kind in Europe. Members up to 30 ft. long can be* **cold pressed.**

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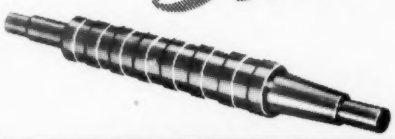
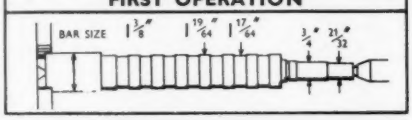
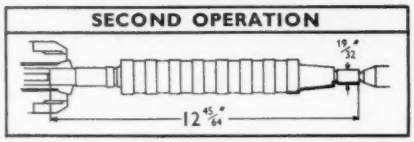


FIRST OPERATION



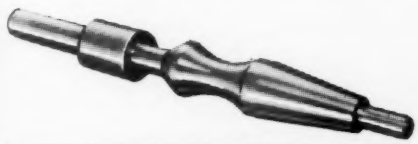
SECOND OPERATION



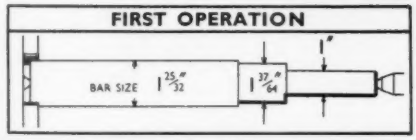
Material St 60. 11
First operation 138 secs.
Second operation 67 secs.
Total time

3 minutes 25 seconds

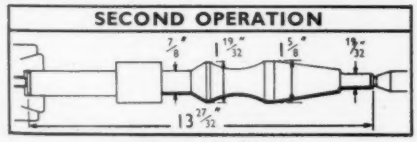
These lathes copy direct from a workpiece or from a 1:1 templet. Hydraulic power is applied to the feed and rapid return of the longitudinal slide. Parts with shoulders of 90°, tapers, concave or convex forms, etc., are produced in very fast times to a high degree of accuracy and with fine finish. Height of centres $4\frac{11}{16}$". Available with distance between centres $15\frac{3}{4}$" or $25\frac{5}{8}$".



FIRST OPERATION



SECOND OPERATION



Material St 50. 11
First operation 137 secs.
Second operation 251 secs.
Total time

6 minutes 28 seconds

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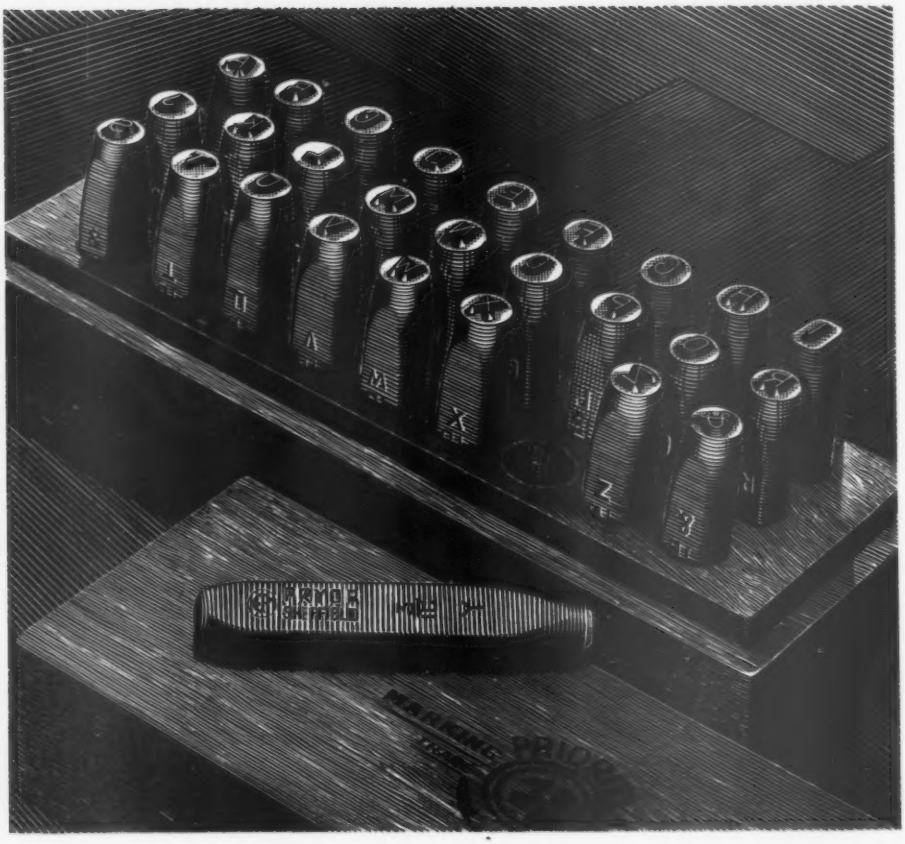

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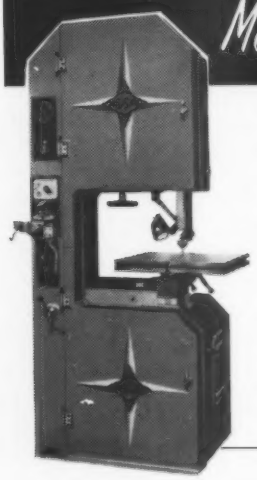

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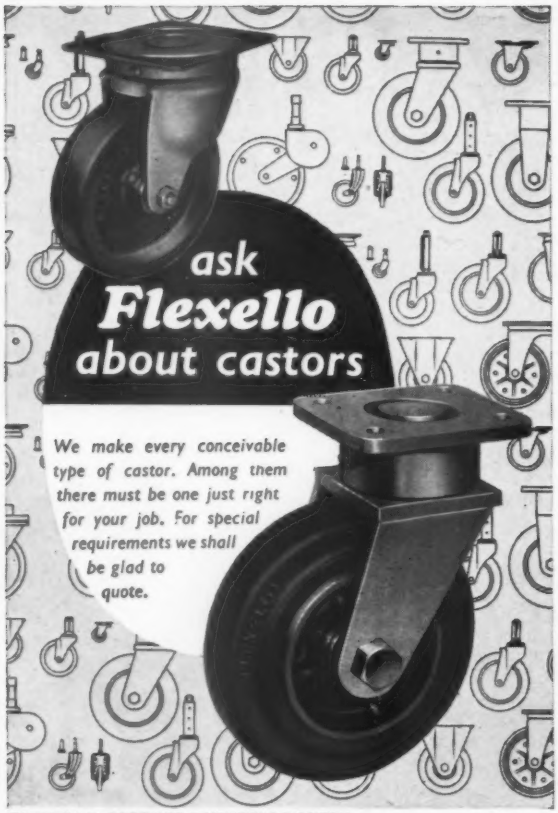
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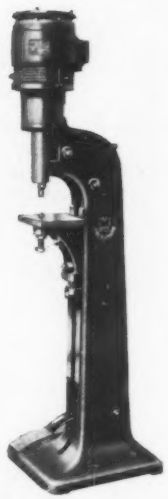

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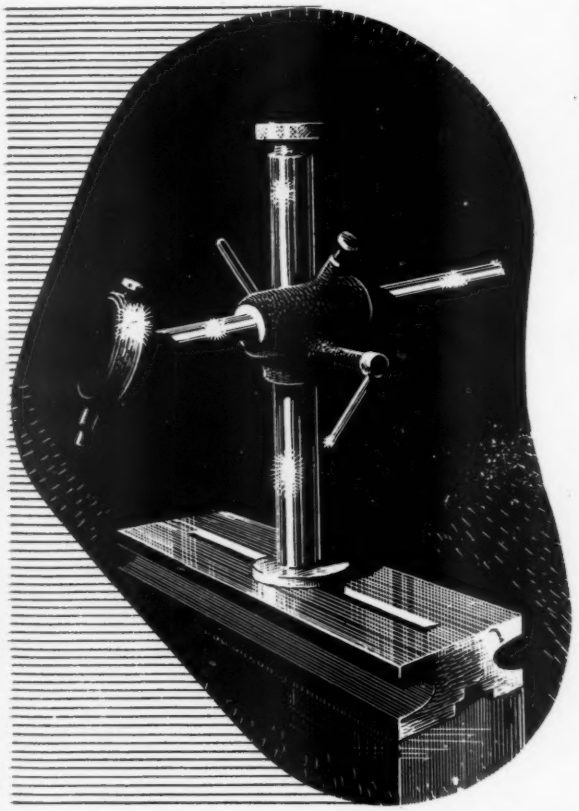

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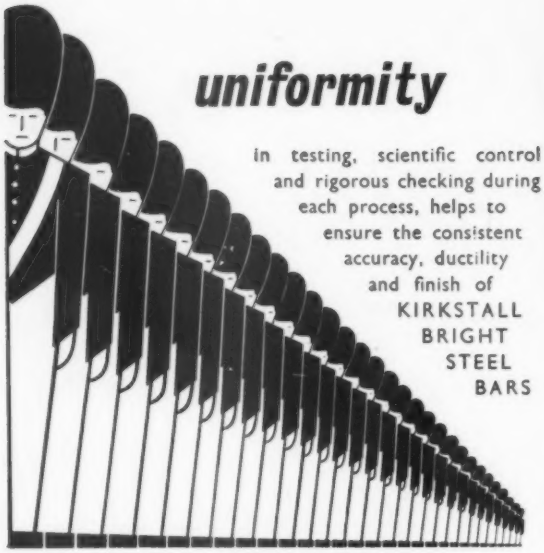

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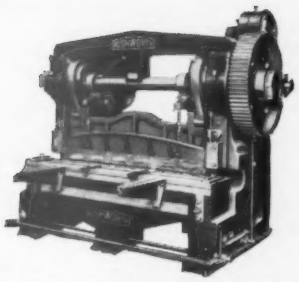

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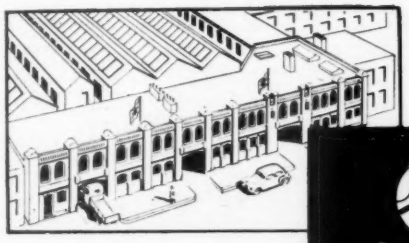

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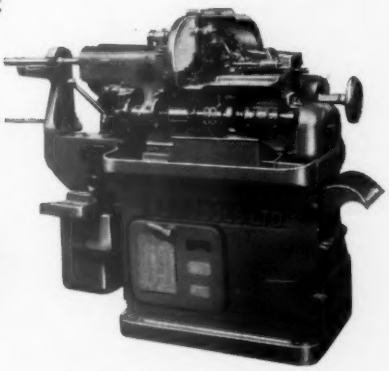

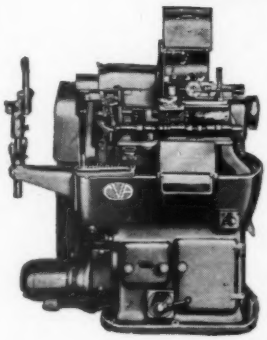

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